U.S. DEPARTMENT OF COMMERCE
National Technical Information Service
PB80-141344

Motor Vehicle Emissions Inspection/Maintenance Program for Tennessee

Systems Control, Inc, Anaheim, CA

Prepared for

Environmental Protection Agency, Atlanta, GA Region IV

Mar 79

United States
Environmental Protection
Agency

Air Programs Branch
Region IV
Atlanta, Georgia 30305

EPA 904/9-79-030
February 1979

PB80-141344

Air

EPA

Motor Vehicle Emissions Inspection/Maintenance Program for Tennessee

Final Report

REPRODUCED BY
NATIONAL TECHNICAL
INFORMATION SERVICE
U.S. DEPARTMENT OF COMMERCE
SPRINGFIELD, VA. 22161

EPA 904/9-79-030

TECHNICAL REPORT DATA
(Please read Instructions on the reverse before completing)

1. REPORT NO. [redacted]

2.

3. RECIPIENT'S ACCESSION NO. PB 80 141344

4. TITLE AND SUBTITLE
Motor Vehicle Inspection/Maintenance for the State of Tennessee

5. REPORT DATE March 1979

6. PERFORMING ORGANIZATION CODE

7. AUTHOR(S)
John Gunderson
Emil J. Vodonick
Gary Pan
David Clark
Jim Gatacre

8. PERFORMING ORGANIZATION REPORT NO.

9. PERFORMING ORGANIZATION NAME AND ADDRESS
Systems Control, Inc.
421 East Cerritos Avenue
Anaheim, California 92805

10. PROGRAM ELEMENT NO.

11. CONTRACT/GRANT NO. 68-02-2536

12. SPONSORING AGENCY NAME AND ADDRESS
U.S. Environmental Protection Agency
345 Courtland Street
Region IV,
Atlanta, Georgia 30305

13. TYPE OF REPORT AND PERIOD COVERED

14. SPONSORING AGENCY CODE

15. SUPPLEMENTARY NOTES

16. ABSTRACT

This document was prepared to assist the Tennessee Department of Public Health in the evaluation and development of a Motor Vehicle Inspection/ Maintenance (I/M) program for the State. I/M was designated by the Clean Air Act Amendment of 1977 as one method by which ambient air quality standards can be achieved by 1982. If standards cannot be attained by 1982 by other means, an extension of compliance to 1987 may be obtained, in which case I/M implementation will be mandatory.

begin

This report presents an analysis of costs and benefits associated with I/M programs that could be implemented in Tennessee. Study efforts were limited to geographic areas with populations over 200,000 where National Ambient Air Quality Standards (NAAQS) are exceeded. These areas are: Nashville (Davidson County), Chattanooga (Hamilton County), Knoxville (Knox County) and Memphis (Shelby County). Four I/M programs administrative options were studied. These were: state administration, contractor administration, county administration and private-garage operations. Only the engine idle-mode option was investigated due to the higher equipment and operating costs of other inspection methods.

17. KEY WORDS AND DOCUMENT ANALYSIS

a. DESCRIPTORS	b. IDENTIFIERS/OPEN ENDED TERMS	c. COSATI Field/Group
Automobile Engine Exhaust Exhaust detection Exhaust emissions Inspection/maintenance	Mobile Source Emission Control Inspection/Maintenance	

18. DISTRIBUTION STATEMENT Unlimited Distribution	**19. SECURITY CLASS** *(This Report)* Unclassified	**21. NO. OF PAGES** 421
	20. SECURITY CLASS *(This page)* Unclassified	**22. PRICE**

EPA Form 2220-1 (9-73)

MOTOR VEHICLE EMISSIONS
INSPECTION/MAINTENANCE
PROGRAM FOR
TENNESSEE

FINAL REPORT

BY:

JOHN GUNDERSON
EMIL J. VODONICK
GARY PAN
DAVID D. CLARK
JIM GATACRE

SYSTEMS CONTROL, INC.
ENVIRONMENTAL ENGINEERING DIVISION
421 EAST CERRITOS AVENUE
ANAHEIM, CALIFORNIA 92805

IN ASSOCIATION WITH:

PACIFIC ENVIRONMENTAL SERVICES, INC.
SANTA MONICA, CALIFORNIA

PROJECT OFFICER
WALLY JONES
U.S. ENVIRONMENTAL PROTECTION AGENCY REGION IV
ATLANTA, GEORGIA

This report has been reviewed by the Air Programs Branch, U.S. Environmental Protection Agency, and approved for publication. Approval does not signify that the contents necessarily reflect the views and policies of the U.S. Environmental Protection Agency, nor does mention of trade names or commercial products constitute endorsement or recommendation for use.

FOREWORD

Motor vehicle inspection and maintenance (I/M) was designated by the Clean Air Act Amendment of 1977 as one method by which ambient air quality standards can be achieved by 1982. If standards cannot be attained by 1982 by other means; an extension of compliance to 1987 may be obtained, in which case I/M implementation will be mandatory. In accordance with this refinement, the United States Environmental Protection Agency (EPA) contracted with Systems Control, Inc., in association with Pacific Environmental to study motor vehicle emission I/M program as might be applied in Tennessee.

The Final Report of this study contains five parts. Part I of the report presents an executive summary of the findings and results.

Part II is made up of a series of technical memoranda which give generalized background information on an I/M program.

Part III of this report completely describes the conduct of the study, and provides the detailed findings and results of the technical and economic analyses. Part IV presents references and bibliography. Part V includes the appendices consisting technical information and USEPA memorandums.

ABSTRACT

This document was prepared to assist the Tennessee Department of Public Health in the evaluation and development of a Motor Vehicle Inspection/ Maintenance (I/M) program for the State. I/M was designated by the Clean Air Act Amendment of 1977 as one method by which ambient air quality standards can be achieved by 1982. If standards cannot be attained by 1982 by other means, an extension of compliance to 1987 may be obtained, in which case I/M implementation will be mandatory.

This report presents an analysis of costs and benefits associated with I/M programs that could be implemented in Tennessee. Study efforts were limited to geographic areas with populations over 200,000 where National Ambient Air Quality Standards (NAAQS) are exceeded. These areas are: Nashville (Davidson County), Chattanooga (Hamilton County), Knoxville (Knox County) and Memphis (Shelby County). Four I/M programs administrative options were studied. These were: state administration, contractor administration, county administration and private-garage operations. Only the engine idle-mode option was investigated due to the higher equipment and operating costs of other inspection methods.

CONTENTS

Section **Page**

Foreword . . . iii
Abstract . . . iv
Figures . . . vi
Tables . . . vi

PART I

EXECUTIVE SUMMARY . . . 1
1.0 Why an Inspection/Maintenance Program . . . 1
  1.1 Inspection/Maintenance Programs . . . 3
  1.2 I/M Implementation Schedule . . . 9
2.0 Background of this Study . . . 12
3.0 Study Findings . . . 14
  3.1 Assumptions . . . 14
  3.2 I/M Program Costs . . . 18
  3.3 Consumer Fee . . . 23
  3.4 Costs of Repair . . . 26
  3.5 Emission Reduction Benefits . . . 28
  3.6 Fuel Economy Benefits . . . 29
  3.7 Indirect Impacts and Political Issues . . . 30
4.0 References . . . 35

PART II
BACKGROUND DOCUMENTATION FOR ALTERNATIVE I/M PROGRAMS

1 INTRODUCTION . . . 39

2 BACKGROUND TECHNICAL MEMORANDA . . . 43
2.1 National Ambient Air Quality Standards . . . 43
  2.1.1 Origin of the Standards . . . 43
  2.1.2 Health Effects of Air Pollutants . . . 45
2.2 Nonattainment Areas for Photochemical Oxidants and Carbon Monoxide in the State of Tennessee . . . 46
2.3 Clean Air Act Amendments (CAAA) Requirements for I/M Program . . . 58
  2.3.1 CAAA Requirements . . . 58
  2.3.2 Potential EPA Sanctions . . . 63
2.4 I/M Program Effectiveness in Reducing Hydrocarbon and Carbon Monoxide Emissions from Light-Duty Vehicles . . . 63
  2.4.1 Emission Reduction Potential . . . 63
  2.4.2 Results of California Study . . . 65
2.5 Technical Memorandum Comparing Loaded-Mode and Idle-Mode Testing Techniques as to Relative Costs and Benefits . . . 68
  2.5.1 Introduction . . . 68

(continued)

Section | Page

2.5.2 Technical Evaluation. 69
2.5.3 Benefits and Costs. 76
2.5.4 Comparison of Benefits and Costs Between Idle-Mode and Loaded-Mode 95

3 GENERAL DEFINITIONS 105

PART III
TECHNICAL AND ECONOMIC ANALYSES

1 INTRODUCTION. 113
1.1 Program Description 114
1.2 Cost Methodology. 114
1.2.1 Construction Costs. 115
1.2.2 Other Capital Costs 115
1.2.3 Initial Implementation Costs. 115
1.2.4 Annual Operating Costs. 116
1.2.5 Consumer Protection Costs 117
1.3 Assumptions 118

2 DATA BASE AND METHODOLOGIES 121
2.1 Program Description 121
2.2 Unit Cost Related Data. 121
2.2.1 Construction Costs. 121
2.2.2 Other Capital Costs 132
2.2.3 Initial Implementation Costs. 138
2.2.4 Annual Operating Costs. 142
2.2.5 Consumer Protection Costs 147
2.3 Personnel 155
2.3.1 Operations Personnel. 158
2.3.2 Administrative. 158
2.3.3 Quality Control Field Support 159
2.3.4 Support Personnel 163
2.4 Sensitivity of Costs to Land Requirements Per Station . . . 163
2.5 Geographic Area and Air Quality 167
2.6 Vehicle Projections 167
2.7 Test Mode 171
2.7.1 Idle-Mode Test. 171
2.7.2 Output Evaluation for Idle-Mode Test. 173
2.8 Administrative Options. 173
2.8.1 Tax Considerations. 175
2.8.2 Personnel Requirements. 175
2.8.3 Program Flexibility 175
2.8.4 Funding Interest Rate 176
2.9 Enforcement 176
2.10 Public Information. 177

(continued)

Section | Page

2.11 Benefits Data 177
2.11.1 Emissions Standards 177
2.11.2 Fuel Savings Data and Methodology 178

3 COST ANALYSIS - OPTION 1. 181
3.1 Option Definition 181
3.2 Facilities Requirements 182
3.3 Option Costs. 184
3.4 Consumer Fee. 185

4 COST ANALYSIS - OPTION 2. 193
4.1 Cost Analysis 193
4.2 Consumer Fee. 202

5 COST ANALYSIS - OPTION 3. 203
5.1 Cost Analysis 203
5.2 Consumer Fee. 205

6 COST ANALYSIS - OPTION 4. 211
6.1 Facilities Requirements 212
6.2 Personnel Requirements. 212
6.3 Cost Analysis 213
6.4 Consumer Fee. 216

7 BENEFIT ANALYSIS. 217
7.1 Tail Pipe Emissions Reduction 217
7.2 Fuel Savings Benefits 218
7.3 Effect on Vehicle Performances and Effect on Vehicle Life. 218
7.4 Failure Rate and Estimated Repair Costs 220
7.5 Value of Warranty Repair Performed. 220

8 INDEPENDENT PROGRAM VARIABLES 221
8.1 Enforcement 221
8.1.1 Vehicle Registration. 221
8.1.2 Change of Ownership 222
8.2 Repair Analyses and Consumer Protection 222
8.2.1 Lead Agency Designation 222
8.2.2 Implementation of Emission Repair Consumer Protection Program. 224
8.2.3 District Responsibility of Consumer Protection Implementation. 232
8.3 Quality Assurance 234
8.3.1 Inspection and Maintenance Equipment Standards. 234
8.3.2 Inspection System Quality Assurance Plan. 238
8.4 Data Management System Design 244
8.5 Legislative Considerations. 261
8.5.1 Impact on Low-Income Groups 263

(continued)

Section Page

8.5.2 Impact on the Repair Industry 264
8.5.3 Consumer Protection 264
8.5.4 Legislative Implementation. 264
8.6 Mechanics Training. 266
8.6.1 Mechanic Curricula. 267
8.6.2 Mechanic Qualification/Certification. 271
8.7 Inspection Station Facilities 271
8.8 Program Funding 272
8.9 Inspection Frequency. 272

9 I/M PROGRAM IMPLEMENTATION SCHEDULE 275
9.1 USEPA Requirements. 275
9.2 Implementation Schedule 277
9.2.1 Pilot Program Schedule. 277
9.2.2 Mandatory Implementation Schedule 277

PART IV

REFERENCES AND BIBLIOGRAPHY 299

PART V

APPENDICES

A MEMO FROM THE UNITED STATES EPA TO REGIONAL EPA ON I/M POLICY. 307
B EFFECT OF STRINGENCY FACTOR 319
C EMISSION CREDITS GIVEN IN THE CODE OF FEDERAL REGULATIONS 325
D LOADED-MODE TRUTH CHART AND DIAGNOSTIC PROCEDURES 335
E SHORT TEST EMISSIONS STANDARDS AS RELATED TO FEDERAL TEST PROCEDURES 345
F ADMINISTRATIVE OPTIONS. 357
G VEHICLE MILES TRAVELED DATA 369
H DETAILED PROGRAM COSTS FOR OPTION 4 387
I COST AND FEE CALCULATIONS 423

FIGURES

Number Page

PART I
EXECUTIVE SUMMARY

1 Nonattainment Counties for HC/CO Requiring I/M Program. . 2
2 Functional Administrative Chart 15
2b Modifications to Reflect Contractor Decentralized System and County Administered System 16

PART II
BACKGROUND DOCUMENTATION FOR ALTERNATIVE I/M PROGRAMS

2-1 Tennessee Counties Nonattainment for Ozone. 59
2-2 Nonattainment Counties for CO 60
2-3 Possible Post Maintenance Deterioration Functions Short Run 85
2-4 Hypothetical Vehicle Life Cycle 86

PART III
TECHNICAL AND ECONOMIC ANALYSES

2-1 One Position Two-Lane Idle-Mode Test Facility 124
2-2 System Block Diagram. 130
2-3 Block Diagram for Library Search. 131
2-4 Three-Lane/Referee Facility 136
2-5 Inner Office and Test Area Three-Lane/Referee Facility. . 137
2-6 Mechanics Needed Versus Work Burden 149
2-7a Functional Administrative Chart 156
2-7b Modifications to Reflect Contractor Decentralized System and County Administered System 157
2-8 Tennessee Counties Nonattainment for Ozone. 168
2-9 Nonattainment Counties for CO 169
2-10 Idle Inspection and Repair Functions. 172
8-1 Station Certification Procedure 242
8-2 Example of Test Facility Data Flow. 248
8-3 Example of Inspection Program Report Format 249
8-4 Example of Rejection Slip for Visual Inspection 250
8-5 Emissions Control Systems Repair Summary. 254
8-6 Continuation Sheet for Additional Repair Information. . . 255
8-7 Manual Data Encoding Format 258
8-8 Example of Daily Operations Summary Worksheet 262
9-1 Pilot Program Timeline. 278
9-2 I/M Program Implementation Schedule for the State Operated Facilities 280
9-3 I/M Program Implementation Schedule for the Contractor Operated Facilities 283
9-4 I/M Program Implementation Schedule Decentralized System - Service Center Operated. 288

TABLES

Table **Page**

PART I
EXECUTIVE SUMMARY

1 Qualitative Comparison of Administrative Program Options 5
2 Existing I/M Program Summary. 8
3 Typical I/M Problems, Solutions and Achievements. 10
4 Options Studied 13
5 Outline of Program Cost Category/Elements 19
6 Total Costs for I/M Program for State Administered Options Operating From 1982 Through 1987 - Manual System Only 20
7 Total Costs for I/M Programs for County Administered Option Operating From 1982 Through 1987 - Manual System Only 22
8 I/M State Manpower Requirements 21
9 State/County Personnel Requirements for Various Option. 24
10 Average Vehicle Population Used in Consumer Fee Calculation 25
11 Consumer Fee of I/M Program 26
12 Arizona Service Industry Repair Cost for Failed Vehicles. 27
13 Repair Cost Summary for Existing I/M Programs 27
14 HC Reduction. 28
15 CO Reduction. 29
16 Yearly Fuel Savings as a Result of I/M. 30

PART II
BACKGROUND DOCUMENTATION FOR ALTERNATIVE I/M PROGRAMS

2-1 National Air Quality Standards Established in 1971. . . . 44
2-2 Federal Ambient Air Quality Standards 47
2-3 Effects of Air Pollution. 48
2-4 Visual Range in a Polluted Atmosphere 55
2-5 Air Pollution Damage to Various Materials 56
2-6 Added Costs of Living in Dirty Environment. 57
2-7 Hydrocarbons Emission Reduction 66
2-8 Carbon Monoxide Emission Reduction. 67
2-9 Comparison of Emissions and Fuel Consumptions Reductions and Repair Costs with Other Studies 65
2-10 Malfunction Truth Table for Idle Testing. 72
2-11 Summary of Errors of Omission and Commission by Regime. . 75

(continued)

Table Page

2-12 Characteristics of Idle Mode and Loaded Mode Testing. . . 77
2-13 Testing Lane Configurations 78
2-14 First Year of Program Credits 81
2-15 Subsequent Years Program Credit 81
2-16 Mechanic Training First Year Credits. 82
2-17 Mechanic Training Subsequent Year Credits 82
2-18 Light-Duty Vehicle Exhaust Emission Reductions from Inspection/Maintenance Programs as of December 31, 1987. 83
2-19 Existing I/M Program Summary. 90
2-20 Average Repair Cost by Vehicle Model-Year 92
2-21 Service Industry Repair Costs 92
2-22 Average Repair Costs for Failed Vehicles. 93
2-23 Effect of Reducing the Maximum Repair Cost. 94
2-24 Comparison of Emissions and Fuel Consumption Reductions and Repair Costs from Other Studies 96
2-25 General Benefits Comparison of Test Modes 97
2-26 General Cost Comparison of Test Modes 98
2-27 MVI Program Costs - Southern California 100
2-28 Idle Regime Standards MVIP Surveillance Study State of California 104

PART III
TECHNICAL AND ECONOMIC ANALYSES

2-1 Outline of Program Cost Category/Elements 122
2-2 Advertised Performance Specifications of Exhaust Gas Analyzers 127
2-3 Computer Costs. 128
2-4 Cost Estimate for a New One Position Two-Lane Idle-Mode Inspection Facility 133
2-5 Mobile Unit Costs Per Unit. 134
2-6 Referee Station Equipment Costs 135
2-7 Correlation Vehicle Cost Per Unit 138
2-8 One-Time Implementation Costs 139
2-9 Test Facility Maintenance, Supplies and Utility Costs Per 2-Lane Idle-Mode Site 143
2-10 Equipment Maintenance Costs for a 2-Lane Idle Station . . 144
2-11 Estimated Program Costs for Mechanic Training 150
2-12 Initial/Ongoing Public Information Program for One Year . 152
2-13 Capital/Operating Costs Associated with Consumer Complaint Follow-Up and Service Industry Field Check . . . 153
2-14 Assumed Cost Expenditures for Vehicle Test Scheduling . . 155
2-15 Personnel Requirement and Personnel Costs for a Two-Lane Idle Station 158
2-16 Administrative Personnel Requirements and Yearly Costs. . 160

(continued)

Table **Page**

2-17 Quality Control Field Personnel Per Unit Basis Per Year . . . 161
2-18 Support Service Costs . . . 164
2-19 Normalizing Factors for Construction Costs . . . 165
2-20 Normalizing Factors for Other Capital Costs . . . 165
2-21 Normalizing Factors for Initial Implementation Costs . . . 165
2-22 Normalizing Factors for Facility Operating Costs . . . 166
2-23 Normalizing Factors for Consumer Protection Costs . . . 166
2-24 Vehicle Population Projections . . . 170
2-25 Testing Lane Configurations . . . 174
3-1 Test Lane and Facility Requirements Year-1982 . . . 183
3-2 Construction Costs Option - State-Operated, Idle Test Year - 1982 . . . 186
3-3 Other Capital Costs Option - State-Operated, Idle Test Year - 1982 . . . 187
3-4 Initial Implementation Costs Option - State-Operated, Idle Test Year - 1982 . . . 188
3-5 Operating Costs Option - State-Operated, Idle Test . . . 189
3-6 Consumer Protection Costs Option - State-Operated, Idle Station . . . 190
3-7 Annualized Costs of I/M Program - Option 1, Manual Test System . . . 191
4-1 Construction Costs Option - Contractor-Operated, Idle Test . . . 195
4-2 Other Capital Costs Option - Contractor-Operated, Idle Test . . . 196
4-3 Initial Implementation Costs Option - Contractor-Operated, Idle Test . . . 197
4-4 Operating Costs Option - Contractor-Operated, Idle Test . . . 198
4-5 Consumer Protection Costs Option - Contractor-Operated, Idle Station . . . 199
4-6 Annualized Costs of I/M Program - Option 2 . . . 201
5-1 Number of Private Garages . . . 204
5-2 Capital Costs Option - Private-Garage Operated, Idle Mode, Year 1982 . . . 204
5-3 Initial Implementation Costs Option - Private Garage Operated, Idle Test, Year - 1982 . . . 205
5-4 Operating Costs Option - Private Garage-Operated, Idle Test . . . 206
5-5 Consumer Protection Costs Option - Private Garage-Operated, Idle Station . . . 207
5-6 Annualized Costs of I/M Program - Option 3 . . . 208
6-1 I/M Program Operations Personnel Requirements - Option 4 - Centralized System . . . 213
6-2 Administrarive Personnel Requirement and Yearly Costs Option 4 . . . 214
6-3 Total Costs for I/M Programs for County Administered Option Operating from 1982 Through 1987 - Manual System Only . . . 215

(continued)

Table		Page
6-4	Consumer Fee - Option 4	216
7-1	HC Reduction	219
7-2	CO Reduction	219
7-3	Estimated Fuel Savings With an I/M Program	218
7-4	Estimated Average Repair Costs FR LDV and HDV for Various Failure Rate for 1983 and 1987 - Idle Mode	220
8-1	Ability of Repair Facilities to Follow the MVIP Repair Procedures	227
8-2	Repaired Vehicles Which Failed Reinspection	228
8-3	Average Repair Costs - Failed Vehicles	230
8-4	Daily Operational Checks and Adjustments	239
8-5	Malfunction Truth Table	252
8-6	Content of Training Courses	268
9-1	Legend Used in the Mandatory Implementation Schedules	279
9-2	Items Required by USEPA in the Implementation Schedule	291
9-3	Footnotes for MIS-I	292
9-4	Footnotes for MIS-II	293
9-5	Footnotes for MIS-III	295

EXECUTIVE SUMMARY

1.0 WHY AN INSPECTION/MAINTENANCE (I/M) PROGRAM

Recent ambient air quality data gathered by the Tennessee Air Pollution Control Agency (TAPCP) indicates that the concentrations of carbon monoxide (CO) and/or photochemical oxidants (O_3) in the atmosphere exceed the National Ambient Air Quality Standards (NAAQS) in four metropolitan areas of the State. These are Chattanooga (Hamilton County), Memphis (Shelby County) Knoxville (Knox County) and Nashville (Davidson County). The United States Environmental Protection Agency (USEPA) and the State of Tennessee Department of Public Health (DPH) have designated these counties as nonattainment areas (see Figure 1). All four counties exceed the O_3 levels and Shelby, Knox, and Davidson counties exceed the CO level.

Motor vehicle emissions are a major source of CO and air pollutants incidental to the formation of O_3 in Tennessee. CO is a product of incomplete combustion in internal combustion engines, and O_3 as well as other oxidants, are products of two other components of engine exhaust--hydrocarbons (HC) and oxides of nitrogen (NO_x). HC and NO_x form O_3 and other oxidants in the presence of sunlight by a series of complex reactions. A motor vehicle I/M program is a cost-effective way to reduce CO and HC emissions from motor vehicles. NO_x reductions are not as easily attained. By significantly reducing the CO and HC emissions from in-use motor vehicles in the four nonattainment areas of Tennessee, an I/M program will provide a means to attain the NAAQS.

The Clean Air Act Amendments (CAAA) of 1977 have specific provisions that require the establishment of I/M programs. According to the CAAA, the State was to submit revisions to its State Implementation Plan (SIP) by January 1979, which specifies methods to achieve the NAAQS. These methods include control of

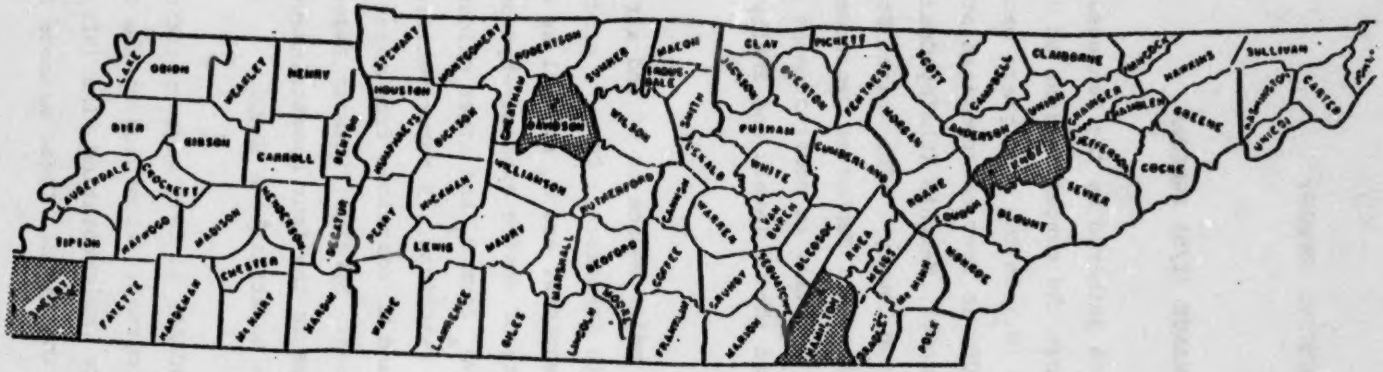

LAKE
OBION
WEAKLEY
HENRY
STEWART
MONTGOMERY
ROBERTSON
SUMNER
MACON
CLAY
PICKETT
SCOTT
CAMPBELL
CLAIBORNE
HANCOCK
HAWKINS
SULLIVAN
JOHNSON
DYER
GIBSON
CARROLL
BENTON
HOUSTON
HUMPHREYS
DICKSON
CHEATHAM
DAVIDSON
TROUSDALE
WILSON
SMITH
JACKSON
OVERTON
FENTRESS
PUTNAM
MORGAN
ANDERSON
UNION
GRAINGER
HAMBLEN
GREENE
WASHINGTON
CARTER
UNICOI
LAUDERDALE
CROCKETT
HAYWOOD
MADISON
HENDERSON
DECATUR
PERRY
HICKMAN
WILLIAMSON
RUTHERFORD
CANNON
DEKALB
WHITE
CUMBERLAND
ROANE
KNOX
JEFFERSON
COCKE
SEVIER
BLOUNT
LOUDON
TIPTON
SHELBY
FAYETTE
HARDEMAN
CHESTER
MCNAIRY
HARDIN
WAYNE
LEWIS
MAURY
LAWRENCE
GILES
MARSHALL
BEDFORD
LINCOLN
MOORE
COFFEE
FRANKLIN
WARREN
GRUNDY
VAN BUREN
SEQUATCHIE
BLEDSOE
RHEA
MEIGS
MARION
HAMILTON
BRADLEY
MCMINN
MONROE
POLK

Figure 1. Nonattainment Counties for HC/CO Requiring I/M Program

stationary sources of air pollution and various transportation control measures whose objective is to reduce vehicle miles traveled (VMT) and hence, reduce pollution from mobile sources. If, in these revisions, the State cannot demonstrate attainment of the NAAQS by 1982 using all reasonably available pollution control measures, then an extension to 1987 can be requested. If an extension is granted, a mandatory I/M program will be required by the CAAA.

1.1 Inspection/Maintenance Programs

Inspection/Maintenance is a two-phase emission control program applied periodically to all in-use vehicles. The inspection portion (Phase 1) of an I/M program serves as a screening procedure to identify vehicles having emissions which exceed established standards. The maintenance portion (Phase 2) of an I/M program involves the repair of those vehicles that exceed the established standards. Vehicles that have failed Phase 2 are required to obtain corrective repair in order to pass a reinspection.

The Federal Motor Vehicle Control Program (FMVCP) was established to ensure that new cars (off the assembly line) are designed to meet increasingly stringent emission standards. Federal testing of in-use vehicles throughout the United States has demonstrated that motor vehicles are not meeting the emission standards for which the vehicles were designed. The reasons they exceed the standards include: improper or inadequate maintenance, tampering, defective emission control devices, and use of improper fuel. Regardless of the cause, it has become clear that in-use vehicle emission inspection programs are necessary to ensure that the emission controls on vehicles continue to operate as they were intended over their useful life.

1.1.1 Program Organizational Approach

A variety of approaches have been used to run I/M programs, but the major types are generally in three organizational categories:

- Government - Centralized test facilities operated by State, city, or local government.

- o **Contractor** - Centralized test facilities operated by a private corporation under contract to the State/local government.
- o **Private Garage** - Decentralized test facilities operated by private automobile service garages, certified or licensed by the State/local government.

Each type of administrative program is compared qualitatively by identifying responsibilities, functions, and roles in the emission test process as shown in Table 1. In each program, the government plays an integral part by auditing records, maintaining quality control checks, certifying contractor or private stations, and assuring consumer protection.

1.1.2 Background Information on Present I/M Programs

I/M programs currently operating throughout the country are presented in Table 2. All available information is summarized under the following categories: program type, size of subject vehicle population, emission test, station requirements, cost (i.e., capital and operational), and consumer fee charges.

Government I/M programs can be further subdivided into either State or municipally-owned/operated programs. New Jersey operates a state program that annually idle-tests 3.9 million light-duty vehicles (LDVs) at 38 stations (62-lane total capacity). This requires $2.5 and $1.3 million in capital and annual operating costs, respectively. Oregon idle-tests 0.55 million vehicles at 7 inspection stations on a biennial basis in the City of Portland. Capital costs are $0.38 million for leased facilities, and annual operating costs are $2.22 million. Consumer fee is $5.00 per vehicle.

Municipally-operated programs are operating in Ohio (Cincinnati), and Illinois (Chicago). These programs annually inspect 0.2 to 1 million vehicles. Ohio has only one test facility, but intends to expand the program later. Illinois operates five 2-lane capacity test facilities. In addition, Illinois operates six mobile test facilities. Ohio capital cost is $13,000 and annual

Table 1. QUALITATIVE COMPARISON OF ADMINISTRATIVE PROGRAM OPTIONS

COST CATEGORIES AND CONSIDERATIONS	GOVERNMENT-OPERATED TEST FACILITIES	CONTRACTOR-OPERATED TEST FACILITIES	PRIVATE GARAGE-OPERATED TEST FACILITIES
Instrumentation and Technology	Design, requirements analysis, and specification development is required.	Will have expertise in these areas.	Will have some basic expertise, but will need to be expanded.
Site Acquisition	Initial capital cost required.	Low capital cost to state, deferred to operational charge:	Capital invested already.
Facility Construction and Acceptance	Capital investment required, local government approval to meet zoning laws.	Contractor agency will require building inspection approval by the State and local government.	Facilities available.
Equipment Acquisition and Installation	Volume discount.	Moderate cost volume discount.	Each participating garage will have to purchase equipment that it does not already have.
Maintenance and Support, Inspection-Oriented Equipment	Preventive maintenance done by facility personnel; major corrective maintenance done either by a single technical department or contracted outside service; moderate cost to State.	Minor corrective maintenance done by facility personnel; major corrective maintenance done by contracted service; no cost to State.	Preventive and minor corrective maintenance done by facility personnel; major corrective maintenance probably done by contracted service; no cost to State.
Quality Control and Support Activities	Periodic confidence testing and calibration functions; minor repairs of supporting equipments done by facility personnel; major repairs done by single department or contracted; moderate cost to State.	Periodic confidence testing and calibration of minimum number of stations by state. Data processing by state.	Performed by State agency. Numerous stations to be checked. Data processing input from card decks.

Table 1. QUALITATIVE COMPARISON OF ADMINISTRATIVE PROGRAM OPTIONS (Continued)

COST CATEGORIES AND CONSIDERATIONS	GOVERNMENT-OPERATED TEST FACILITIES	CONTRACTOR-OPERATED TEST FACILITIES	PRIVATE GARAGE-OPERATED TEST FACILITIES
Program Management and Functions	Maintain records, schedule vehicles, collect fees, review emission results, update standards and documentation, determine future requirements, evaluate newer equipments, determine budgetary requirements, and other program management functions; may involve many separate State agencies, new and/or existing; moderate cost to State.	Similar management functions to State operated program, but with State agency that oversees contractor administration; moderate cost to State.	Requires State to audit all records on regular basis; high cost to State.
Program Management and Administration Surveillance Program	Periodic certification of existing facilities; qualification/certification of new facilities; moderate cost to State.	Periodic certification of contractor facilities by State inspection team; moderate cost to State.	Private-operated facilities certified by State personnel; high cost to State.
Initial Personnel Training and Indoctrination	Single department responsibility; uniform training policy, course content; minimum quantity of trained instructors, equipment, buildings; moderate cost to State.	Require single department responsible for training, etc.; minimal cost to the State.	Possibly many diverse training policies, course contents, equipment, facilities, instructors; requires guidance from State agency on requirements; minimal cost to State.
State Qualification and Certification	Single departmental responsibility; uniform qualification and certification policies; minimum quantity of technical and administrative personnel; moderate cost to State.	State responsibility to supervise initial operation of program; moderate cost to State.	Mandatory that State qualify and certify stations; high cost to State.

Table 1. QUALITATIVE COMPARISON OF ADMINISTRATIVE PROGRAM OPTIONS (Continued)

COST CATEGORIES AND CONSIDERATIONS	GOVERNMENT-OPERATED TEST FACILITIES	CONTRACTOR-OPERATED TEST FACILITIES	PRIVATE GARAGE-OPERATED TEST FACILITIES
Vehicle Scheduling	Single departmental responsibility.	Mandatory that State be responsible.	Mandatory that State be responsible.
Facility Inspection Personnel Salaries, wages, etc.	Technical rating dependent on test regime; cost proportional to technical requirements; salaries and benefits must be competitive to attract higher-rated personnel; high cost to State.	Technical rating dependent on test regime requirements.	Technical rating depends on test regime; cost proportional to technical rating.
Quality Assurance	Responsible for complete audit of all records; complete data analysis; adjusting confidence limits; moderate cost to State.	Calibration records frequently audited by State personnel; State responsible for complete data analyses; moderate cost to State.	Difficult to implement because of instrument differences, diversified personnel; high cost to State.

Table 2. EXISTING I/M PROGRAM SUMMARY

PROGRAM TYPE	STATE	ADMINISTRATIVE AGENCY	VEHICLE POP (Millions)	TEST MODE AND STRINGENCY[a]		STATION STATUS			COST (Millions $ Yr)		INSPECTION FEE
				L.D.V.	H.D.V.	#Lanes	#Sta.	Mobile	Capital[b]	Operating[b]	
I. GOVERNMENT A. State	New Jersey	DMV - EPA	3.9 LDVs	Idle 23%	NA	62	38	1	$2.50 (1972) +	$1.33	$3.50 including safety
	Oregon[c] Portland	Dept. of Environ. Qual.	0.55 LDVs (biennial)	Idle 40%	NA	14	7	1	$0.38 Leased facil. (1975)	$2.22	$5
B. Municipal	Ohio, Cincinnati	Cincinnati APCD[d]	0.2 LDVs	Idle 30%	NA	4	1	None	$13k & safety facil.	$0.13 for	$3.75 including safety
	Illinois, Chicago	Chicago Dept. Env. Control	1.1 LDVs	Idle 30-35%	NA	10	5	6	$2.0 (1973)	$1.45 (1977)	Free[e,f]
II. CONTRACTOR	Arizona,[g] Maricopa and Pima counties	Ariz. Dept./ Health Ser.	1.1 cars, trucks, and motorcycles	Idle[h] 30%	EPA City	36	12	1	$10.5	$4.0	$5
	California	Air Resources Board	1.5 LDVs	Idle 30%	NA	44	17		NA	NA	$11(1979)
III. PRIVATE GARAGE	Nevada (Clark Co. only)	Dept. Motor Vehicles and Dept. Human Resources	0.20 LDVs	Idle	NA	218 Licensed Private Stations			$0.17 (1974)	$0.43 approx. (1974)	$10.00-$33.00 (including adjustments)
	Rhode Island	Dept. of Transportation	0.5 LDVs	Idle 30%	NA	923 Private Garages + 1 State-Operated challenge lane			$1.00 (1977)	Part of Capital cost	$4 1st year

[a] Percent of vehicle failing to meet established standards.

[b] Cost data defined per particular year. To upgrade costs to present year multiply by appropriate inflation factor.

[c] State of Oregon, Oregon Environmental Quality Commission - "Report to the Oregon Legislature on the Motor Vehicle Emission Testing Program," January 14, 1977.

[d] Air Pollution Control Department.

[e] Included as part of the registration fee.

[f] Chicago's program costs are covered by a city sticker fee.

Definitions: DMV - Department of Motor Vehicles.
LDV - Light-Duty Vehicle (GVW 8501 lb.).
HDV - Heavy-Duty Vehicle (GVW 8500 lb.).

[g] State of Arizona, Bureau of Vehicular Emissions Inspections - "Tune-up for Less Emission - It's Working Arizona Vehicular Emissions Inspection Program Operations", 1977.

[h] Loaded test with only idle fail/pass standards.

operating cost is $0.13 million. Illinois expenditures are $2.0 million for capital costs and $1.45 million annual operating expenses.

In the State of Arizona (maricopa and Pima Counties), contractor-operated systems have been established. The 12 test facilities annually process an estimated 1.1 million cars, trucks, and motorcycles using a 30-percent stringency factor with idle test requirements. Capital cost expenditures are estimated at $10.5 million with annual operating costs approaching $4.0 million. Starting in 1979, California has established a contractor-operated inspection network in Southern California Air Basin. This program inspects all light-duty vehicles transfer of ownership. Current consumer fee is $11.00.

At present, Nevada and Rhode Island are the only states that have private garage-operated I/M programs. Rhode Island has an extensive program, testing 0.5 million vehicles at 923 certified private garages. The Nevada program is comparatively smaller, licensing only 218 garages to test 200,000 vehicles. As expected, the capital cost expenditure for Rhode Island is quite large compared to Nevada. Unexpectedly, the cost to the motorist is quite high for Nevada ($10.00 to $33.00) compared to Rhode Island ($4.00). However, the Nevada program does have vehicle adjustment included in the test requirements.

Typical problems encountered during implementation and their subsequent solutions for each type of I/M program are shown in Table 3. Additional information includes representative achievements for each state I/M program.

1.2 I/M Implementation Schedule

In producing an I/M SIP revision, the state must provide for:

1. An analysis of the benefits and costs of the program
2. A public information effort
3. A legislative proposal
4. A schedule for I/M implementation

Table 3. TYPICAL I/M PROBLEMS, SOLUTIONS AND ACHIEVEMENTS

PROGRAM TYPE	STATE & RESPONSIBLE AGENCY	PROBLEMS	SOLUTIONS	ACHIEVEMENTS
I. GOVERNMENT-OPERATED				
A. State-Operated	California	.(Pilot Program) Minimal Problems		.Public Reaction Excellent .Unique Combination of Exhaust Analysis, Engine Monitoring, and Computer Technology .Diagnostic Testing
	New Jersey	.2-Year Exemption for New Cars .Lack Operating Capital Capacity Improvements Cannot be Made .DMV Resistant to Increased Refailure Rate Expected in Phase III standards (23%) .Refailure Rate is 25%	.Legislation Pending .Funding Has Increased $330,000 .No Position Change .Refailure Rate Now 11%	.Nation's Longest On-Going I/M Program .4,700 Garages Now Utilizing Exhaust Analyzers .Private Garage Reinspection Program
	Oregon Portland	.Biennial Inspection Lowers Program Effectiveness, Created Cash Flow and Personnel Problems .Tampering	.Inspection Period Will be Shortened .Trying to Implement An Annual Inspection Cycle, Requires Legislation Action	.Estimates Reduction of HC is 14% and CO 7% .Private Garage Acceptance is Increasing
B. Municipal-Operated	Ohio Cincinnati	.Low Throughput .Inadequate Enforcement .No Phase-In Period and No P.R. Program .Mechanics Inadequately Trained	.Improved Enforcement Led to Increased Throughput .P.R. Program Needed .Mechanic Training Program	.Demonstrated Short Lead Time in Adding I/M Program to Safety Program
	Illinois Chicago	.Less Than 20% of Registered Vehicles Have Been Inspected	.Increased Enforcement Policies .Favor Mandatory Inspection with Three Conditions: 1. Fed. Govt. and Auto Manufacturer's Concurrence On Warrantee Program 2. Auto Manufacturer's Compliance With Existing Statutory Emission Standards 3. I/M Implementation Over Regional Area	.Communication Channels Established with Auto Manufacturers Regarding High Emission Levels of Late Model Vehicles .Nation's First Fully Automated Inspection Program

Table 3. TYPICAL I/M PROBLEMS, SOLUTIONS AND ACHIEVEMENTS (Continued)

PROGRAM TYPE	STATE & RESPONSIBLE AGENCY	PROBLEMS	SOLUTIONS	ACHIEVEMENTS
II. CONTRACTOR-OPERATED	Arizona Maricopa and Pima Counties	.Initial Adverse Public Reaction .Queuing Problems .Tampering .Inadequate Inspector Training	.Expected to Disappear With Increased Efficiency and Better Public Awareness .Needs Contractor Monitoring	.Nation's First Contractor-Operated Program
III. PRIVATE GARAGE-OPERATED	Nevada Clark County	.Minimal		.DMV Control of Licensing of Stations and Inspectors .Minimal Cost
	Rhode Island	.Inadequate Training of Garage Mechanics .Some Garages Violated Regulations	.On-Going Mechanic Training Program .Constant Monitoring Needed	.Program Initiated by Governor and Rhode Island DOT With Backing From Executive and Legislative Branches .State-Run Inspection Facility Used as Reference Station

Before January 1, 1979, an SIP revision was prepared by DPH and submitted to the EPA. As a part of the SIP revision submittal itself, a commitment was made to review an I/M program as an emission reduction program in accordance with the schedule noted in the quotation from Reference 1.

"Normally, adequate legal authority to implement a SIP revision must exist for a revision to be approved. Where a legislature has had adequate opportunity to adopt enabling legislation before January 1, 1979, the Regional Administrator should require certification that adequate legal authority exists for I/M implementation by January 1, 1979. However, for many states there will be insufficient opportunity to obtain adequate legal authority before their legislatures meet in early 1979. Therefore, a certification of legal authority for the implementation in these states must be made no later than June 30, 1979. An extension to July 1, 1980 is possible, but only when the state can demonstrate that a) there was insufficient opportunity to conduct necessary technical analyses and/or b) the legislature has had no opportunity to consider any necessary enabling legislation for inspection/maintenance between enactment of the 1977 Amendments to the Act and June 30, 1979. Certification of adequate legal authority, or other evidence that legal authority has been adopted, must be submitted to the EPA Regional Offices to be included in the SIP revision already submitted. Failure to submit evidence of legal authority by the appropriate deadline will constitute a failure to submit an essential element of the SIP...."

Further quotation from Reference 1:

"Implementation of I/M 'as expeditiously as practicable' shall be defined as implementation of mandatory repair for failed vehicles no later than 2-1/2 years after passage of needed legislation or certification of adequate legal authority for new centralized systems (State or Contractor-operated), and 1-1/2 years after legislation or certification for decentralized systems which are adding emission inspections to safety inspections. For the normal legislation deadline of June 30, 1979, new centralized programs must start by December 31, 1981, and all others must start by December 31, 1982, while all other programs must start by December 31, 1981. Where I/M can be implemented more expeditiously, it must be. Each state implementation schedule must be looked at individually to determine if it is as expeditious as practicable...."

2.0 BACKGROUND OF THIS STUDY

In order to comply with requirements of the CAAA of 1977, the USEPA contracted to study alternative I/M options as might be applied in the State of Tennessee.

The initial effort of Task 1 was the development of background data regarding the technical and administrative aspects of I/M programs. A summary report that described I/M program elements and other states' experience in I/M and various technical memoranda was produced to provide a general understanding of I/M programs.

The purpose of Task 2 was to analyze the various options in terms of cost and benefits so that the DPH can consider several options in their SIP to meet NAAQS.

The cost/benefits analysis was completed upon the following scenarios:

Table 4. OPTIONS STUDIED

	SCENARIO			
FUNCTION	1	2	3[a]	4
Administration	State	contractor	county	private-garage
Test Mode	idle	idle	idle	idle
Enforcement	vehicle registration	vehicle registration	vehicle registration	vehicle registration
Vehicle Categories[b]	LDV, LDT_1, and LDT_2	LDV, LDT_1, and LDT_2	LDV, LDT_1, and LDT_2	LDV, LDT_1, and LDT_2
Stringency	30 percent	30 percent	30 percent	30 percent
Area Coverage	four county[c]	four county[c]	four county[c]	four county[c]
Data Handling	manual	manual	manual	manual

[a] County option is further classified as to emission test station administration by county, contractor, or private-garage.

[b] LDV - light-duty vehicle passenger car 12 or less passengers.
LDT_1 - light-duty trucks - 6,000 or less gross vehicle weight.
LDT_2 - light-duty trucks - 8,500 or less gross vehicle weight.

[c] The State and contractor test stations were also costed to reflect semi-automated and automated operation.

In addition to the program considerations listed in Table 4, there are a number of support services that are important to I/M effectiveness and cost, but do not directly influence option selection. These support services include:

- Quality Assurance
- Mechanic Training
- Consumer Protection
- Public Education

The eventual implementation of an I/M program will require the cooperation of several different state offices. Figure 2 provides a functional outline of the activities as they relate to I/M needs and requirements. Use of existing facilities, services and resources should greatly reduce the cost of support services.

3.0 STUDY FINDINGS

3.1 Assumptions

The methodology used in this report was based upon the following assumptions:

- The program operation is over a period of 6 years starting in 1982
- Double-lane facilities will be built
- The private garages in Option 4 of Table 4 would assume the cost of purchasing test equipments
- To cover general administration (G/A) and certain overhead costs, not identified in the cost categories, the following assumptions were made:
  - G/A is 15 percent
  - Undefined overhead such as certain indirect costs related to supplementary personnel, administrative, accounting, purchasing, financial, etc., activities is assumed to be 50 percent

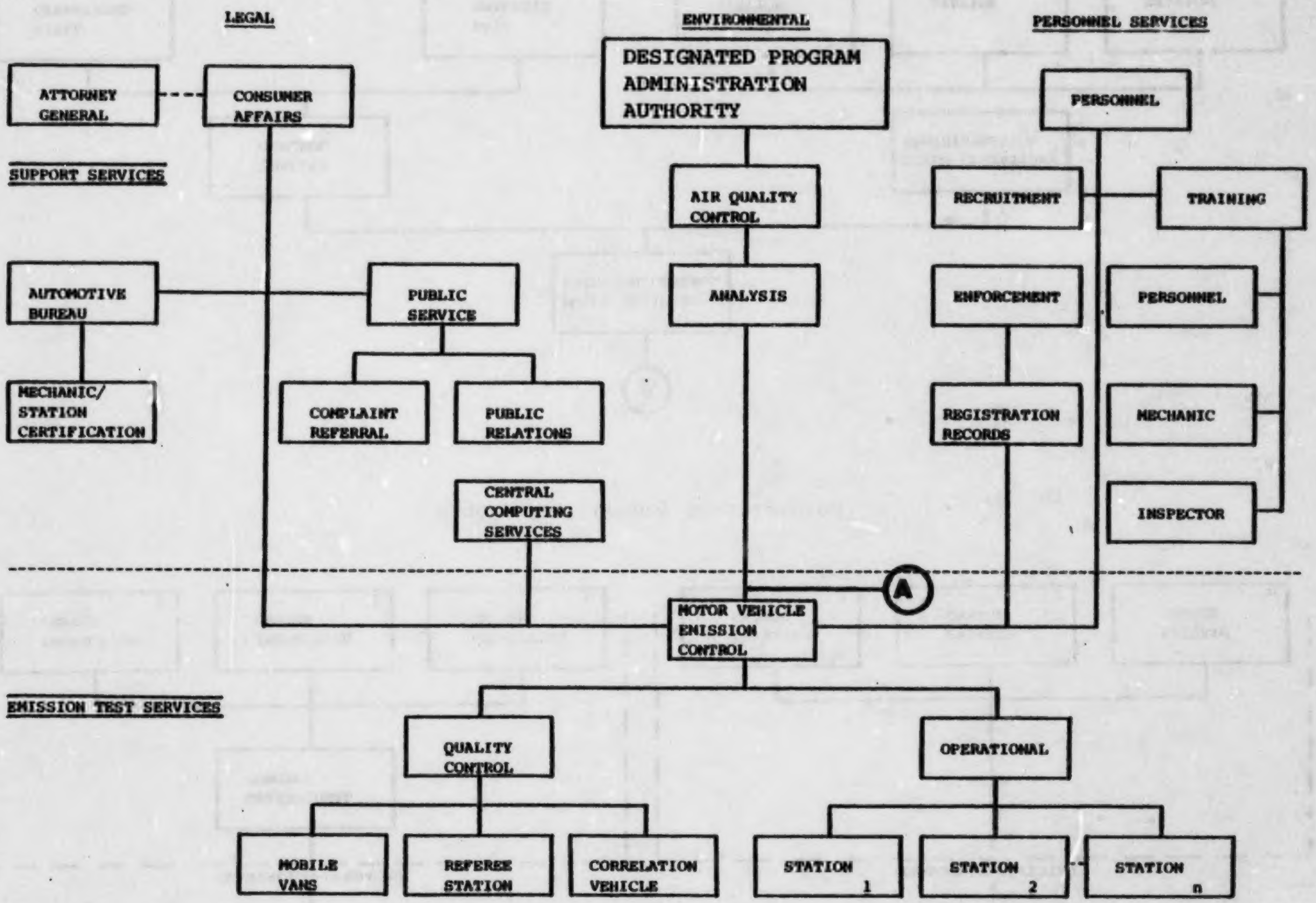

LEGAL
ENVIRONMENTAL
PERSONNEL SERVICES
ATTORNEY GENERAL
CONSUMER AFFAIRS
DESIGNATED PROGRAM ADMINISTRATION AUTHORITY
PERSONNEL
SUPPORT SERVICES
AIR QUALITY CONTROL
RECRUITMENT
TRAINING
AUTOMOTIVE BUREAU
PUBLIC SERVICE
ANALYSIS
ENFORCEMENT
PERSONNEL
MECHANIC/ STATION CERTIFICATION
COMPLAINT REFERRAL
PUBLIC RELATIONS
REGISTRATION RECORDS
MECHANIC
CENTRAL COMPUTING SERVICES
INSPECTOR
A
MOTOR VEHICLE EMISSION CONTROL
EMISSION TEST SERVICES
QUALITY CONTROL
OPERATIONAL
MOBILE VANS
REFEREE STATION
CORRELATION VEHICLE
STATION 1
STATION 2
STATION n

Figure 2. Functional Administrative Chart

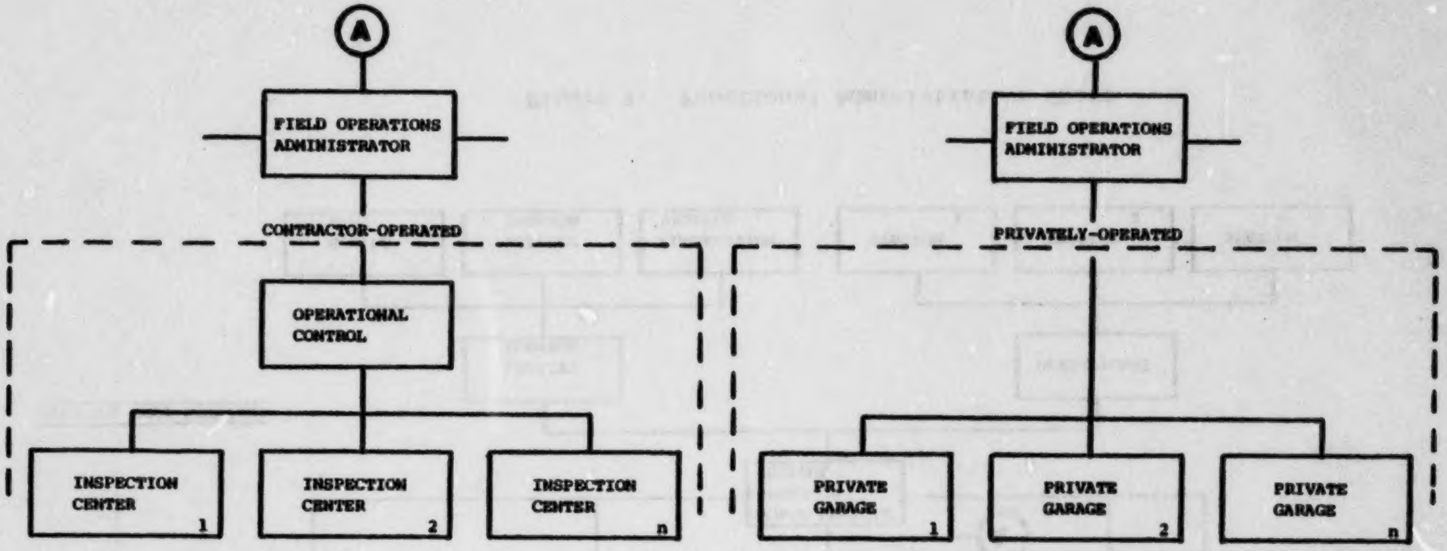

A
FIELD OPERATIONS ADMINISTRATOR
CONTRACTOR-OPERATED
OPERATIONAL CONTROL
INSPECTION CENTER 1
INSPECTION CENTER 2
INSPECTION CENTER n
A
FIELD OPERATIONS ADMINISTRATOR
PRIVATELY-OPERATED
PRIVATE GARAGE 1
PRIVATE GARAGE 2
PRIVATE GARAGE n

Figure 2a. County Administered

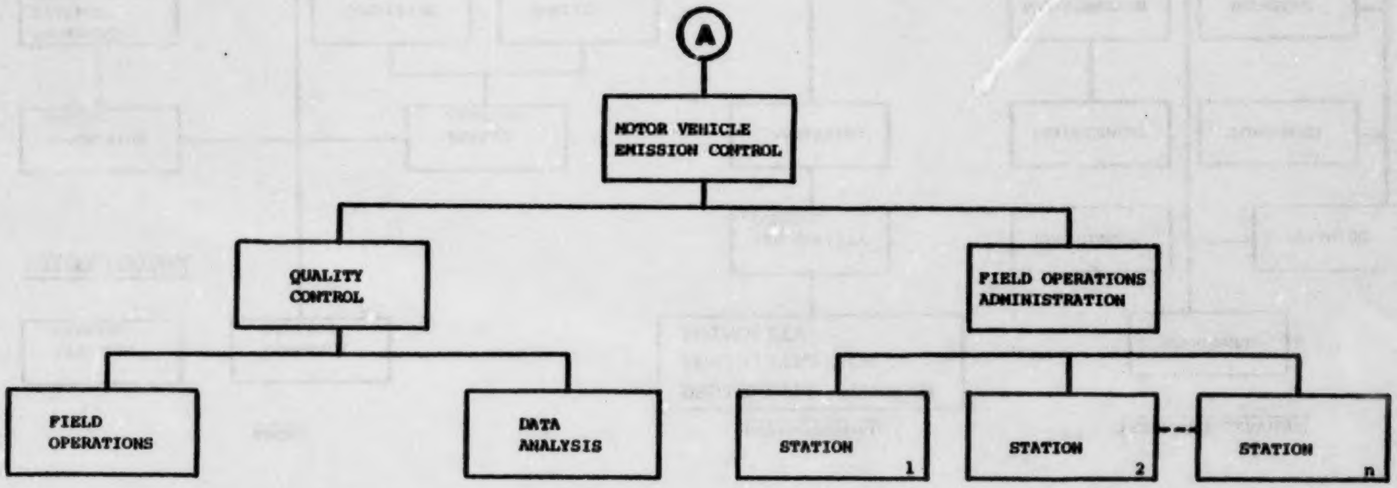

A
MOTOR VEHICLE EMISSION CONTROL
QUALITY CONTROL
FIELD OPERATIONS ADMINISTRATION
FIELD OPERATIONS
DATA ANALYSIS
STATION 1
STATION 2
STATION n

Figure 2b. Modifications to Reflect Contractor Decentralized (Private Garage) System and County Administered System

  - Contractor's profit is 10 percent
  - A factor of 1.73 (= 1.15 x 1.50) will apply to direct labor and other direct charges (ODC) for the state option
  - A factor of 1.90 (= 1.55 x 1.50 x 1.10) will apply to direct labor, ODC's and profit for the contractor option

- Capital investment per private garage is $4,000. This includes cost of emission testing and auxiliary equipment

- Operation's throughput time is 3.75 minutes

- Mechanics cost (including overhead) is $18.00 per hour

- The total number of private garages that would participate in the program was assumed to be 578.

- Predicted emissions data was supplied by the State of Tennessee Department of Transportation.

- Cost of capital is 6 percent for the State.

- The State personnel benefits including sick leave, vacation, retirement, insurance, holidays, etc., is 17 percent of base rate.

- Fuel cost is $0.75 per gallon.

- At an inflation rate of 7 percent, the compound factor for 1982, assuming a 1978 base, is 1.311, and for 1987 it is 1.838.

- Indirect costs reflecting the cost to consumers for waiting time at inspection lanes and cost of transportation to and from the inspection and repair facilities were ignored.

- Average miles traveled per year for LDVs is 11,500 miles per year.

- Failed vehicles consumed 3.8 percent more fuel than the FMVCP certified vehicle on an average.

- Assumed miles-per-gallon fleet average for LDVs is 20 miles-per-gallon (1982), 24 miles-per-gallon for (1987).

- Existing vehicle emission facilities in Hamilton and Shelby Counties were not considered in the cost evaluation.

3.2 I/M Program Costs

Each of the alternative I/M programs under evaluation involves an extremely large number of fixed and variable cost items. To facilitate cost comparisons among the alternatives, cost items were grouped and listed in Table 5.

The cost classifications in Table 5 were designed to provide expected aggregate cost for the various program options. This approach does not provide a cost accounting treatment of required program expenditures. Program indirect costs, such as overhead, G/A, and profit, are included as percentages of the total annualized direct costs. The intention was to design a tool that allows cost items to be readily identified and analyzed.

3.2.1 I/M Program Costs

The major cost components for the various options are summarized in Tables 5 and 6. The costs are identified as to State costs, county costs, contractor costs and/or private garage as appropriate.

1. State-Administered Program - Table 6 presents costs for State, contractor and private-garage administered test facilities. The total 6-year costs for the State-administered test facilities is estimated at $36 million; for contractor-administered test facilties is estimated at $38.9 million; and for 578 private-garage administered test facilities is estimated at $21.1 million.

TABLE 5. OUTLINE OF PROGRAM COST CATEGORY/ELEMENTS

Item	Activity
I.	CONSTRUCTION COSTS (CAPITAL INVESTMENT)
1.	Land and Off Site Improvement Cost
	a. Land Cost
	b. Off Site Improvement Costs
2.	Facility Cost
	a. Construction Cost
3.	Instrumentation Cost
	a. Primary Test Equipment
	b. Ancillary/Maintenance Equipment
4.	Office Equipment
5.	Computer Costs
	a. Hardware
	b. Software
II.	OTHER CAPITAL COSTS
1.	Administrative Office Equipment
2.	Quality Control Equipment
	a. Mobil Unit
	b. Referee Station
	c. Correlation Car
3.	Consumer Complaint
4.	Vehicle Test Scheduling
III.	INITIAL IMPLEMENTATION
1.	Site Selection
2.	Bids Preparation and Evaluation
3.	Design of Facility
4.	Training Plan Development
5.	Personnel Selection
6.	Document Preparation
7.	Administrative Support
8.	Initial System Certification
9.	System Integration and Checkout
IV.	ANNUAL OPERATING COSTS
1.	Facility Operating Costs
	a. Personnel Costs
	b. Maintenance and Miscellaneous Item Costs
	1. Facility
	2. Equipment
2.	Quality Control Operating Costs
	a. Administrative Supply Costs
	b. Mobil Unit and Referee Lane Maintenance Operation Costs
	c. Correlation Vehicle Operation Costs
3.	Support Costs
	a. Administrative
	b. Data Analysis
	c. Fee Collection and Vehicle Registration
	d. Training
V.	CONSUMER PROTECTION COSTS
1.	Mechanic Training
2.	Public Information Program
3.	Complaint Follow-Up
	a. Consumer Affairs
4.	Vehicle Test Scheduling Costs

Table 6. TOTAL COSTS FOR I/M PROGRAM FOR STATE ADMINISTERED OPTIONS OPERATING FROM 1982 THROUGH 1987 - MANUAL SYSTEM ONLY (1978 Dollars)

	TEST FACILITY ADMINISTRATION		
COST ITEM	STATE (Option 1)	CONTRACTOR (Option 2)	PRIVATE GARAGE (Option 3)
1. Construction			
o State	3,593,900	100,000	-
o Contractor	-	3,493,900	-
o Private Garage	-	-	2,312,000[a]
2. Other Capital			
o State	411,800	411,800	411,800
3. Initial Implementation			
o State	273,100	44,900	70,100
o Contractor	-	228,200	-
o Private Garage	-	-	173,400
4. Subtotal (1,2, & 3) Plus Total Interest Payment[b]			
o State	5,220,800	679,300	588,000
o Contractor	-	4,541,500	-
o Private	-	-	3,032,600
5. Operation Costs			
o State	11,715,900	2,409,000	2,409,000
o Contractor	-	9,621,900	-
o Private Garage	-	-	6,252,000
6. Consumer Protection			
o State	3,851,000	3,851,000	3,851,000
o Contractor	-	-	-
o Private Garage	-	-	-
7. Subtotal (4,5, & 6)			
o State	20,787,700	6,939,300	6,848,000
o Contractor	-	14,163,400	-
o Private Garage	-	-	9,284,600
8. Overhead, G/A, and Profit			
o State (@ 73%)[c]	15,175,000	5,065,700	4,999,000
o Contractor (@ 90%)[c]	-	12,747,100	-
o Private Garage[d]	-	-	-
9. Subtotal (7 & 8)			
o State	35,962,700	12,005,000	11,847,000
o Contractor	-	26,910,500	-
o Private Garage	-	-	9,284,600
GRAND TOTAL	35,962,700	38,915,500	21,131,600

[a] Cost for instrumentation, $4,000 per private garage.

[b] Amortization factor with 6% interest rate is 0.20336. Hence, subtotal (1,2, & 3) + total interest payment = subtotal (1,2, &3) x 0.20336 x 6 = subtotal (1,2, &3) x 1.2202.

[c] See Section 3.1 for assumptions.

[d] Included in mechanic's hourly rate. See Section 3.1 for detail.

2. County-Administered Program - Table 7 presents the costs for Davidson, Hamilton, Knox and Shelby counties. The costs are further identified to the county-administered test facilities, contractor-administered facilities, private-garage administered program, and the State cost to support a county-administered program in the area of reporting, analyses, and USEPA coordination.

Comparing with the first three options, option 4 would require slightly higher program costs for each operation alternative. Their program costs are summarized as follows:

OPERATION ALTERNATIVE	OPTION (In Millions - 1978 Dollars)			
	1	2	3	4
State/County	36	-	-	36.3
Contractor	-	38.9	-	39.2
Private Garage	-	-	21.1	21.6

Option 4 would require additional 0.3 million for both state/county and contractor operation, and 0.5 million extra if private-garage operation takes place.

3.2.2 Comparison of State Manpower Requirements

Table 8 lists the State personnel requirements for each test facility administered option.

Table 8. I/M STATE MANPOWER REQUIREMENTS

JOB CATEGORY	TEST FACILITY ADMINISTRATION		
	State	Contractor	Private Garage
Program Administrator	1	1	1
Assistant Program Administrator (QC)	1	1	1
Assistant Program Adm. (Testing)	1	1	1
Environmental Engineer	3	3	3
Statistician	2	2	2
Clerical	27	6	6
Secretaries	1	1	1
Inspection Agents	8	8	8
Test Technicians	105		
TOTAL	149	23	23

Table 7. TOTAL COSTS FOR I/M PROGRAMS FOR COUNTY ADMINISTERED OPTION (4) OPERATING FROM 1982 THROUGH 1987 - MANUAL SYSTEM ONLY (In Thousands of 1978 Dollars)

COST ITEM	DAVIDSON COUNTY County	DAVIDSON COUNTY Contractor	DAVIDSON COUNTY Private Garage	HAMILTON COUNTY County	HAMILTON COUNTY Contractor	HAMILTON COUNTY Private Garage	KNOX COUNTY County	KNOX COUNTY Contractor	KNOX COUNTY Private Garage	SHELBY COUNTY County	SHELBY COUNTY Contractor	SHELBY COUNTY Private Garage
1. Construction												
o State[a]	29	29	0	14	14	0	15	15	0	42	42	0
o County	998.3	0	0	499.1	0	0	499.1	0	0	1,497.4	0	0
o Contractor	-	998.3	-	-	499.1	-	-	499.1	-	-	1,497.4	-
o Private Garage[b]	-	-	640	-	-	352	-	-	352	-	-	968
2. Other Capital												
o State[a]	22.3	22.3	22.3	10.8	10.8	10.8	11.1	11.1	11.1	31.9	31.9	31.9
o County	38.4	38.4	38.4	38.4	38.4	38.4	38.4	38.4	38.4	38.4	38.4	38.4
3. Initial Implementation												
o State	0	0	0	0	0	0	0	0	0	0	0	0
o County	102.5	38.5	35.3	74.6	37.3	26.4	74.6	37.3	26.4	135.1	39.7	72.6
o Contractor	-	64	-	-	37.3	-	-	37.3	-	-	95.4	-
o Private Garage	-	-	48	-	-	33.8	-	-	33.8	-	-	41.8
4. Subtotal (1,2, &3) Plus Total Interest Payment[c]												
o State	62.6	62.6	27.2	30.3	30.3	13.2	31.9	31.9	13.5	90.2	90.2	38.9
o County	1390.1	93.8	89.9	746.9	92.4	79.1	746.9	92.4	79.1	2038.8	95.3	135.4
o Contractor	-	1296.2	-	-	654.5	-	-	654.5	-	-	1943.5	-
o Private Garage	-	-	839.5	-	-	470.8	-	-	470.8	-	-	1232.2
5. Operation Costs												
o State[a]	329.4	329.4	329.4	168	168	168	170.4	170.4	170.4	468	468	468
o County	3063	433.8	433.8	1748.4	433.8	433.8	1748.4	433.8	433.8	4377.6	433.8	433.8
o Contractor	-	2719.2	-	-	1359.6	-	-	1359.6	-	-	4078.8	-
o Private Garage	-	-	1826.1	-	-	892.9	-	-	910.2	-	-	2623
6. Consumer Protection												
o State	939	939	939	456.4	456.4	456.4	469.6	469.6	469.6	1350.4	1350.4	1350.4
o County	157.2	157.2	157.2	76.2	76.2	76.2	78.6	78.6	78.6	226.2	226.2	226.2
o Contractor	-	0	-	-	0	-	-	0	-	-	0	-
o Private Garage	-	-	0	-	-	0	-	-	0	-	-	0
7. Subtotal (4,5, &6)												
o State	1331	1331	1295.6	654.7	654.7	637.6	671.9	671.9	653.5	1908.6	1908.6	1857.3
o County	4610.3	684.8	680.9	2571.5	602.4	589.1	2573.9	604.8	591.5	6642.6	755.3	795.4
o Contractor	-	4015.4	-	-	2014.1	-	-	2014.1	-	-	6022.3	-
o Private Garage	-	-	2665.6	-	-	1363.7	-	-	1381	-	-	3855.2
8. Overhead, G/A, And Profit												
o State (@ 73%)[d]	971.6	971.6	945.8	477.9	477.9	465.5	490.5	490.5	477.1	1393.3	1393.3	1355.8
o County (@ 73%)[d]	3365.5	499.9	497.1	1877.2	439.8	430	1879	441.5	431.8	4849.1	551.4	581
o Contractor (@ 90%)[d]	-	3613.9	-	-	1812.7	-	-	1812.7	-	-	5420.1	-
o Private Garage[a]	-	-	0	-	-	0	-	-	0	-	-	0
9. Total (7 & 8)												
o State	2302.6	2302.6	2241.4	1132.6	1132.6	1103.1	1162.4	1162.4	1130.6	3301.9	3301.9	3213.1
o County	7975.8	1184.7	1178	4448.7	1042.2	1019.1	4452.9	1046.3	1023.3	11491.7	1306.7	1376.4
o Contractor	-	7629.3	-	-	3826.8	-	-	3826.8	-	-	11442.4	-
o Private Garage	-	-	2665.6	-	-	1363.7	-	-	1381	-	-	3855.2
GRAND TOTAL	10,278.4	11,116.6	6,085	5,581.3	6001.6	3,485.9	5,615.3	6,035.5	3,534.9	14,793.6	16,051	8,444.7

[a] State costs were appropriated to local counties, assuming four-county participation. Costs of construction ($100,000), other capital ($76,100), and operation ($1,135,800) for the state are fixed costs. These state costs would have to be redistributed, if fewer counties participate.

[b] Instrumentation cost only. No facility construction needed.

[c] See footnote b in Table 6.

[d] See Section 3.1 for assumptions.

The State administrative personnel requirements do not have a one-to-one correspondence to the number of vehicles because the minimum effort of program administration is independent of the number of vehicles but is required for certain administrative and analyses requirements. Table 9 lists state/county personnel for each county and for each test facility-administered options. Should it be established that all four counties would be required to implement an I/M program, the state personnel complement would still require only 11 persons.

State management responsibilities for any option will include: 1) vehicle test scheduling, 2) record maintenance, 3) establishment and review of emission test limits, 4) data analyses to determine inspection program effectiveness, 5) evaluation of current and future equipment needs, and 6) provision for future analyses and development. These program responsibilities will be coordinated by three key State personnel positions: 1) Program Administrator, 2) Assistant Program Administrator, Quality Control, and 3) Assistant Program Administrator, Test. The for each management position is outlined as follows:

- Program Administrator - Will be responsible for the day-to-day operation of the program.

- Assistant Program Administrator (Quality Control) - Will manage the calibration checks for all inspection centers; and the statistical analysis of emission test data.

- Assistant Program Administrator (Test) - Will be responsible for the efficient day-to-day operation of referee test stations.

3.3 Consumer Fee

The average consumer fee to defray cost for various options is derived by dividing average annual cost in 1978 dollars by average vehicle population (Table 10). Average annual cost is the yearly average cost of the total costs in Tables 6 and 7 evenly distributed over 6 years of program operation.

Table 9. STATE/COUNTY PERSONNEL REQUIREMENTS FOR VARIOUS OPTION[a]

CATEGORY	DAVIDSON COUNTY			HAMILTON COUNTY			KNOX COUNTY			SHELBY COUNTY		
	County	Con-tractor	Private Garage	County	Con-tractor	Private Garage	County	Con-tractor	Private Garage	County	Con-tractor	Private Garage
State												
Administration	2	2	2	2	2	2	2	2	2	2	2	2
Clerical	5	5	5	5	5	5	5	5	5	5	5	5
Environ. Engineer	2	2	2	2	2	2	2	2	2	2	2	2
Analysts	2	2	2	2	2	2	2	2	2	2	2	2
TOTAL	11	11	11	11	11	11	11	11	11	11	11	11
County												
Administration	1	1	1	1	1	1	1	1	1	1	1	1
Quality Control	2	2	2	2	2	2	2	2	2	2	2	5
Test Personnel	30	-	-	15	-	-	15	-	-	45	-	-
Clerical	8	2	2	5	2	2	5	2	2	11	2	2
Environ. Engineer	1	1	1	1	1	1	1	1	1	1	1	1
TOTAL	42	6	6	24	6	6	21	6	6	60	6	6

[a] Support personnel are required in purchasing accounting, field investigator complaints (1 person per county) personnel, training, etc.

Table 10. AVERAGE VEHICLE POPULATION USED IN CONSUMER FEE CALCULATION[a]

COUNTY	VEHICLE POPULATION USED IN CONSUMER FEE CALCULATION
Davidson	288,200
Hamilton	140,900
Knox	143,600
Shelby	413,900
Total	986,600

[a] Vehicle population by taking the average of year 1984 and 1985 projections. Heavy-duty vehicles and motorcycles are not included.

The consumer fees (based upon 1978 dollars) for the options associated with implementing an I/M program are presented in Table 11. The fee allows one retest of a failed vehicle. Counties with less vehicle population such as Hamilton and Knox Counties would have to charge higher consumer fees to balance relatively fixed administrative costs.

Table 11. CONSUMER FEE OF I/M PROGRAM
(In 1978 Dollars)

	EMISSION TEST FACILITY OPERATOR			
PROGRAM CONTROL	State	Contractor	County	Private Garage
State	$6.08	$6.58	-	$3.57
Davidson County	-	6.43	$5.94	3.52
Hamilton County	-	7.10	6.60	4.12
Knox County	-	7.00	6.52	4.10
Shelby County	-	6.46	5.96	3.40

Estimated consumer fee ranges from $3.52 to $7.10. It should be noted that the fee includes assumptions on general administration (G/A), overhead costs, and profit. Comparing with the new California program which costs the consumer $11.00 (see Table 2), the estimated fee for Tennessee I/M program is significantly lower. Many existing programs in other states have maintained their initial fee charge, but not without budget and operation problems. Furthermore, some programs were implemented as add-on programs to safety programs. The incremental costs were much less with existing test facilities.

3.4 Costs of Repair

The maintenance of the I/M program involves the repair of those vehicles that were identified as high emitters; the level of preventative maintenance requested by vehicle owners; and any unnecessary repairs by the service industry.

Average repair costs for all four I/M options is estimated to be $26 to $34 per failed vehicle, based upon 1978 dollars. Since these I/M options are only directly involved in the inspection phase (with possible exception of the private-garage option) vehicles failing inspection standards are directed to a number of independent repair operators.

Recent Arizona I/M experience revealed that the average cost of repairs of failed vehicles was $23.02 during 1977. These costs ranged from zero for warranty repairs to over $600. for an engine overhaul. Table 12 presents the average cost of repairs for various model-year groupings in different facilities performing the repairs.

Table 12. ARIZONA SERVICE INDUSTRY REPAIR COST FOR FAILED VEHICLES

Type Facility	1964-1967	1968-1977	1964-1977
Franchised dealers	$41.25	$26.82	$27.97
Service stations	23.06	19.81	21.14
Merchandisers	15.53	20.29	19.43
Tune-up specialists	36.19	22.86	24.72
Independent garages	21.33	27.46	26.79
"Do-it-yourselfers"	14.27	20.61	19.08

Source: Ref. 2.

Table 13 presents vehicle percent contribution to various repair cost categories for Arizona, Oregon, and New Jersey. Again, the repair costs are less than $10 for 40 to 60 percent of the vehicles tested. Lower repair costs are attributed to minor carburetor adjustments, rather than expensive tune-ups or engine repairs.

Table 13. REPAIR COST SUMMARY FOR EXISTING I/M PROGRAMS

ITEM	ARIZONA	OREGON	NEW JERSEY
Repair Costs			
Less than $10	44%	64%	29.8%
$10 to $25	24%	21%	26.4%
$25 to $50	20%	8%	22.1%
$50 to $100	10%	5%	16.1%
More than $100	2%	2%	5.6%
Number of Vehicles	2,000	1,400	1,600
Median Repair Costs	$15	$8	$20
Percent of Repairs less than average cost	64%	71%	65%

Ref. 8

Other studies, however, indicated the average repair cost would be $36. (in 1977 dollars). (Ref. 3, 4, 5, 6.) Some states have placed a cost ceiling on the amount of repair.

3.5 Emission Reduction Benefits

The levels of emission reduction that result from the implementation of I/M programs depends on the number of vehicles inspected, stringency factor*, function, and also on the travel characteristics in the county where the vehicles are registered.

The calculation of emission reduction as a result of I/M implementation was based on results obtained from the EPA-supported MOBILE1 computer program. This program enables the user to apply I/M program credits to emission factor estimates by inputting a stringency factor and vehicle model-year applicability. Emission levels developed by MOBILE1 program, presented in Tables 14 and 15, detail HC/CO emission levels without I/M; with I/M; and percent emission reduction from I/M implementation; for county and statewide geographic options.

Table 14. HC REDUCTION (TONS/YEAR)

	1977	1982			1987		
COUNTY	Inventory	Without I/M	With I/M	% Reduction	Without I/M	With I/M	% Reduction
Chattanooga	13,170	8,575	8,116	5	5,524	4,139	25
Knoxville	14,128	9,124	8,534	7	5,886	4,089	31
Memphis	28,301	19,259	18,091	6	12,722	9,118	28
Nashville	22,371	14,723	14,333	3	10,088	6,774	33
TOTAL	77,970	51,681	49,074	5	34,220	24,120	30

Source: State of Tennessee, Department of Transportation (Ref. 7).

---

*Stringency factor refers to the percentage of total vehicles tested in an I/M program, in a given time period, that fail inspection and are required to have maintenance performed.

Table 15. CO REDUCTION (TONS/YEAR)

COUNTY	1977 Inventory	1982 Without I/M	1982 With I/M	1982 % Reduction	1987 Without I/M	1987 With I/M	1987 % Reduction
Chattanooga	103,940	79,351	68,297	14	50,577	35,379	30
Knoxville	114,708	84,561	70,469	17	54,042	32,618	40
Memphis	194,164	179,319	151,522	16	118,180	75,256	36
Nashville	180,183	135,302	104,674	23	93,184	57,090	39
TOTAL	592,995	478,533	394,962	18	315,983	200,343	37

Source: State of Tennessee, Department of Transportation (Ref. 7).

This information was provided for 1982 and 1987 I/M program years using 1977 as a base year. The second column for HC and CO shows total emissions in 1977. The third and sixth columns show emissions expected in 1982 and 1987 without an I/M program. The lower figures for both years are attributable to the Federal Motor Vehicle Emission Control Program (FMVCP). The fourth and seventh columns show the amount of emission reduction that would occur with FMVCP and an I/M program. The fifth and eighth columns show the actual percent emission reduction that may be achieved through implementation of an I/M program. In all instances, the percent reduction for each county closely approximates percent reduction achieved over the entire state.

3.6 Fuel Economy Benefits

One of the important benefits of I/M programs, in addition to the reduction in vehicular emissions, is fuel conservation. A properly tuned engine operates with greater efficiency, and therefore, consumes less fuel. This improvement in fuel economy varies somewhat from one program to another but most sources agree that up to a 10-percent fuel economy improvement can be expected between the failed and maintained vehicles.

One of the purposes of an I/M program is to give an incentive to motorists to maintain their cars better than they normally would in the absence of I/M.

This maintenance would increase vehicle-life and prevent problems such as vehicle stalling.

A 3.8 percent fuel economy improvement, per failed vehicle per year (as established from California programs), was used in this study to calculate fuel and dollar savings for the I/M program options. As shown in Table 16, the total energy saved over the 6 years of program operation is 41.43 million gallons. At $0.75 per gallon, vehicle owners would save $31.08 million.

Table 16. YEARLY FUEL SAVINGS AS A RESULT OF I/M[a]

Program Year	Fuel Saving (Millions of gals.)	Fuel Cost Savings (Millions of dollars)	Savings Per Repaired Vehicle
1982	8.09	$6.07	$21.87
1987	5.72	4.29	13.63

[a] Vehicle population projections are based upon miles traveled data supplied by the State of Tennessee.

The lower savings in 1987 reflect the higher proportion of vehicles in-use at that time which meet the more stringent Federal Corporate Average Fuel Economy (CAFE) requirements.

Note that there is no change in program benefits as a result of alternative program administrative options. Theoretically, the number of vehicles tested and the applied stringency factor,* should not vary among the four alternatives.

Fuel cost savings per repaired vehicle would be $21.87 in 1982 and $13.63 in 1987. Less fuel cost savings per vehicle in 1987 is anticipated because of higher fuel efficiency of automobiles.

3.7 Indirect Impacts and Political Issues

In addition to the primary benefits of reducing vehicular emissions, fuel savings, and improving air quality, I/M programs have indirect benefits and bearing on political issues. To discover what the potential benefits and political issues might be, other I/M programs were reviewed.

---

*Ibid.

3.7.1 Indirect Benefits

There are several indirect benefits that do not relate to specific options but would result from the implementation of any I/M program option. These include the following:

- Improved health benefits (less respiratory problems, etc.)
- Improved vehicle performance and vehicle life
- Increased agricultural production
- Reduction of settable particulates and suspended particulates
- Reduction of sulfur oxides (SO), CO, and o_3
- Improvement in visibility
- Conservation of energy

The improvement in air quality in those areas where the NAAQS are currently exceeded are likely to have some benefits in the health of the affected population.

The amount and nature of the benefits would depend on the severity of air pollution prior to the implementation of the I/M program, and the amount of reduction in air pollution resulting from I/M. Increased urbanization and growth in the four nonattainment areas, coupled with stagnant weather conditions, will greatly increase the possibility of severe air pollution episodes.

3.7.2 Political Issues

Political issues surrounding an I/M program are:

- Impacts on low-income citizens

- Potential overcharging for repairs and performance of unnecessary repair work

- Problems of conflict of interest and uniformity of inspection in the private-garage approach

I/M programs have the potential of placing a burden on low-income citizens by forcing them to make expensive repairs for failed vehicles. This could force low-income people who own older vehicles to make needed repair that exceed the value of the vehicle. This problem has been reduced by instituting repair cost ceilings. Thus, if the cost of the repairs needed to meet the standard exceed a cost ceiling, then the vehicle could receive an inspection waiver. A cost ceiling, if implemented, could create administrative problems.

The problem of dealing with repair overcharging or unnecessary repair work can be dealt with in several ways. Some states have instituted recommended repair procedures that are specified for various emission failure problems. These procedures range from an idle adjustment to a low emission tune-up. Mechanic training programs will result in a higher level of repair competence and motivation. Consumer protection programs can be designed to identify those garages that charge significantly more than the average repair cost or identify garages generally drawing numerous consumer complaints. Such procedures can be relatively informal or can be tied in with formal licensing of garages and mechanics.

The options with inspection, as well as repair, in licensed private garages may pose quality assurance and consumer protection problems. With a large number of garages having emission analyzers of varying degrees of quality, and with less uniform supervision, there will probably be less uniformity of the inspection in private garages. Moreover, there is an inherent conflict of interest in having the same garage conduct both the inspection and maintenance phase of I/M.

Public Information Program - Many questions raised by I/M implementation can be properly addressed through a well-designed and comprehensive public information program. It can help to eliminate adverse public criticism by stressing the purpose, objectives, benefits, and operation of I/M. Emphasizing the checks and balances (e.g., quality assurance) designed into the I/M program, and health benefits from emission reductions, will alleviate many problems associated with the implementation procedure.

A public information program can address other benefits to the vehicle owner. Improvements in fuel economy, vehicle performance and longevity are important to vehicle owners. Control of vehicles that emit annoying quantities of smoke, and assurances that I/M requirements will extend to all vehicles, are important points to stress.

This can be accomplished by effective use of advertising techniques that utilize the mass communication media (e.g.; radio, television, newspapers, etc.), information centers, education programs, citizen group contacts, etc. In the early stages of I/M implementation, initial program information should include:

- Explanations that specify derived benefits from automotive emission inspection and maintenance
- Explanations of the inspection procedure

Supplemental information is required after the public has accepted the need to understand the concepts of I/M. This additional information includes:

- The location of test facilities
- Instructions and fee requirements
- Explanation of retest requirements and conditions
- Importance for allowing time for repair and retest, or considerations for waiver (if implemented)
- Explanation of complaint referral system
- Explanation of area covered by I/M program

3.7.3 EPA Sanctions

The Federal government places certain sanction on the availability of Federal funds to a state when the state has not complied with regulations relating to Public Law 95-95. Public Law 95-95, 95th Congress, known as the "Clean Air Act" provides for limitations of certain Federal assistance. Quoting from this Act:

> "Sec. 176. (a) The Administrator shall not approve any projects or award any grants authorized by this Act and the Secretary of Transportation shall not approve any projects or award any grants under title 23, United States Code, other than for safety, mass transit, or transportation improvement projects related to air quality improvement or maintenance, in any air quality control region--
>
> "(1) in which any primary ambient air quality standard has not been attained,
>
> (2) where transportation control measures are necessary for the attainment of such standards, and
>
> (3) where the Administrator finds after July 1, 1979, that the Governor has not submitted an implementation plan which considers each of the elements required by Section 172 or that reasonable efforts toward submitting such an implementation plan are not being made or, after July 1, 1982, in the case of an implementation plan revision required under Section 172 to be submitted before July 1, 1982."

4.0 REFERENCES

1. U.S. Environmental Protection Agency "Inspection/Maintenance Policy" David G. Hawkins, Assistant Administrator for Air and Waste Management, July 1978.

2. State of Arizona, Bureau of Vehicle Emission Inspection, Arizona Department of Health Services, "Arizona Vehicle Emission Inspection Program Operation - 1977," April 1978.

3. State of California, Air Resources Board, "Evaluation of Mandatory Vehicle Inspection and Maintenance Program," August 2, 1976.

4. Northrop Corporation, "Mandatory Vehicle Emission Inspection and Maintenance," Vol. 5, 1971.

5. U.S. Environmental Protection Agency, "Control Strategies for In-Use Vehicle," November 1972.

6. Olson Laboratories, Inc., "Effectiveness of Short Emission Inspection Test in Reducing Emissions Through Maintenance," July 31, 1977.

7. Tennessee Department of Transportion "Emission Inventory for Chattanooga, Knoxville, Memphis and Nashville."

8. Kincannon, F.G., A.H. Castaline, "Information Documents in Automobile Emissions Inspection and Maintenance Programs." Prepared for U.S. Environmental Protection Agency, 1978.

9 Federal government publication "Public Law 95-95, Clean Air Act, August 7, 1977.

Part II

BACKGROUND DOCUMENTATION
FOR
ALTERNATIVE I/M PROGRAMS

Preceding page blank

Section 1

INTRODUCTION

Part I of this final report is to document information on the possible use of vehicle inspection/maintenance (I/M) as a strategy for reducing air pollutant levels in the State of Tennessee. The format of the technical memorandum was developed with the specific intent of allowing distribution to a wide audience, including both technical and nontechnical personnel. Depending on the background of the reviewer and his familiarity with I/M, it will be necessary to examine all or only certain sections of the document. Part II presents a series of technical memoranda giving generalized background information on the following topics:

- The National Ambient Air Quality Standards (NAAQS)--their origin, basis and health implications, particularly with respect to photochemical oxidants and carbon monoxide (CO).

- Geographic description of the nonattainment status of the State with respect to oxidant and CO air quality standards.

- Requirements of the Clean Air Act Ammendments (CAAA) of 1977 as they relate to I/M, including a discussion of the Federal sanctions which may be imposed if states do not comply with these requirements.

- General description of the effectiveness of an I/M program in the reduction of hydrocarbon (HC) and CO from vehicular sources.

Preceding page blank

- Comparison of loaded- and idle-mode testing methods as to relative costs and benefits. This includes the development of cost-scaling factors for the three administrative approaches:
  - State-administered test stations
  - Single contractor-administered test stations
  - Private garage-administered test stations

Part III is a glossary of technical terms commonly used in discussing an I/M program. Part IV provides the references. The appendices which are included in Part V present information and discussion on:

- Memo from the U.S. Environmental Protection Agency (EPA) to the Regional EPA on I/M policy.

- Effect of stringency factor.

- Reprint of Appendix "N".

- Loaded-mode truth chart.

- Short-test emissions standards as related to the Federal Test Procedure (FTP).

- Administrative options.

- Emission-related parts list.

Recent national interest in I/M as a control measure for vehicle emissions was generated by provisions of the CAAA of 1977. Briefly, in accordance with the Amendments, all areas of the country are to achieve ambient air quality standards by 1987 through various measures that provide for such attainment. One method of achieving the 1987 goal is through the implementation of an I/M program. This program must be scheduled and defined in the State Implementation Plan (SIP) for air quality for each nonattainment area by 1982.

Twelve counties in the State of Tennessee have been designated as potentially not attaining ambient air quality standards for photochemical oxidants in 1982. Four counties have been designated as potentially not attaining ambient air quality standards for CO. All areas will have attained air quality standards in nitrogen dioxide (NO_2).

Section 2

BACKGROUND TECHNICAL MEMORANDA

2.1 NATIONAL AMBIENT AIR QUALITY STANDARDS

2.1.1 Origin of the Standards

The basis for the development of the National Ambient Air Quality Standards (NAAQS) was established by Congress through the Air Quality Act of 1967. The Act, as originally adopted, required the Secretary of Health, Education and Welfare to develop and issue criteria of air quality which were requisite for the protection of the public health and welfare. Under the 1967 Act, the states were then expected to develop air quality standards and plans for the implementation of the standards. In May 1971, however, the EPA promulgated national ambient air quality standards for six major pollutants. The Standards as originally adopted are shown in Table 2-1. In subsequent revisions to the Standards by the EPA, secondary standards for certain pollutants were also adopted. These secondary standards were established at levels deemed necessary to protect the public welfare from any known or anticipated adverse effects of a pollutant. The secondary standards were set to prevent harmful effects on animals, vegetation, weather and visibility, and to preserve a certain "quality of life." The current primary and secondary standards are given in Table 2-2.

The latest revisions to the NAAQS have resulted from the 1977 Amendments to the Clean Air Act. Section 109 of the Act was amended to require the EPA to establish an independent scientific committee to review air quality criteria and the NAAQS not later than December 31, 1980 (at subsequent intervals not exceeding 5 years), and recommend revisions in the criteria and standards as may be appropriate. The EPA was also directed to promulgate short-term primary standards for nitrogen dioxide (NO_2) (less than 3 hours within 1 year).

Table 2-1.
NATIONAL AIR QUALITY STANDARDS ESTABLISHED IN 1971

	Level not to exceed	
Pollutant	μg/m³	ppm
SO_2	80[a]	0.03
	365[b]	0.14
Particulate matter	75[c]	
	260[b]	
Carbon monoxide	10[d]	9
	40[e]	35
Photochemical oxidants	160[e]	0.08
Hydrocarbons	160[f]	0.24
Nitrogen oxides	100[a]	0.05

[a] Annual arithmetic mean.

[b] Maximum 24-hr concentration not to be exceeded more than once a year.

[c] Annual geometric mean.

[d] Maximum 8-hr concentration not to be exceeded more than once a year.

[e] Maximum 1-hr concentration not to be exceeded more than once a year.

[f] Maximum 3-hr concentration (6-9 a.m.) not to be exceeded more than once a year.

2.1.2 Health Effects of Air Pollutants

The major air pollutants which are of significance are characterized as follows:

- Particulate matter is generally any matter (less than 500 microns), whether solid or liquid, that is dispersed in the air. Studies indicate an association between particulate matter and certain health effects, especially injury to the respiratory system. Other problems associated with high concentrations of particulate matter are impaired visibility, increased corrosion of some metals, and damage to plants and vegetation.

- Carbon monoxide (CO) emissions arise primarily from incomplete combustion of carbonaceous fuels. Factors such as oxygen concentration, flame temperature, gas residence time, and combustion chamber turbulence are important variables that affect the CO concentrations in exhaust. Carbon monoxide is absorbed into the blood stream within the respiratory tract and reacts primarily with the hemoglobin in red blood cells. This decreases the oxygen-carrying capacity of the blood reducing the amount of oxygen transported to vital tissues.

- Hydrocarbons (HC) are primarily associated with processing and use of petroleum products. They constitute the major portion of the reactive organic substances that produce photochemical oxidant. The only direct effect attributable to high ambient levels of HC (i.e., ethylene) is vegetation damage. Polynuclear HC, some of which are carcinogenic--such as benzol( )pyrene--are primary pollutants arising from a variety of combustion processes. Auto exhaust is a major source of atmospheric polynuclear aromatic HC.

- Photochemical oxidants are produced in the atmosphere when reactive organic substances (mainly HC) and nitrogen oxides are exposed to sunlight. Ozone (O_3) is the major reaction product of these oxidants. Photochemical oxidants at certain concentrations can cause irritation of the mucous memberances, damage to vegetation, and deterioration of materials. They affect the clearance mechanism of the lungs and alter resistance to respiratory bacterial infection.

- Nitrogen oxides (NO_x), namely nitrogen dioxide (NO_2) and nitric oxide (NO), are formed during combustion processes in chemical reactions involving atmospheric nitrogen and fuel-bound nitrogen. The amount formed depends on the temperature of both reactants and products, and the length of time favorable conditions persist for the oxygen-nitrogen reactions. Nitric oxide has not been shown to have any adverse effects on health or welfare. However, there are several atmospheric reactions which can lead to the oxidation of NO to NO_2. Nitrogen dioxide has been associated with a variety of respiratory diseases and is also essential to the production of photochemical smog. Corrosion of electrical components and vegetation damage have been linked to NO_2 at high concentrations.

- Sulfur dioxide (SO_2) is produced by the combustion of fuel in power-generating facilities as well as in automobiles. The effects of SO_2 on health are related to irritation of the respiratory system at low concentrations, destruction of the upper respiratory cilia carry capacity at high concentrations, and reduction to viral resistance in the presence of particulates. Research has also been conducted to study the synergistic effects of particulates and SO_2 in combination as related to corrosion damage.

Tables 2-3 through 2-6 describe in further detail the effects of air pollutants.

2.2 NONATTAINMENT AREAS FOR PHOTOCHEMICAL OXIDANTS AND CARBON MONOXIDE IN THE STATE OF TENNESSEE

Recently, the Tennessee Air Pollution Control Agency (TAPCA)had identified 4 counties as air quality nonattainment areas. Specifically, they are Davidson,

Table 2-2.
FEDERAL AMBIENT AIR QUALITY STANDARDS

POLLUTANT	AVERAGING TIME	FEDERAL	
		Primary	Secondary
Carbon Monoxide	8 hrs	9.0 ppm[a] (10 mg/m^3)	Same as primary standards
	1 hr	35.0 ppm (41 mg/m^3)	
Nonmethane hydrocarbons	6-9 a.m.	0.24 ppm[a] (160 $\mu g/m^3$)	Same as primary standards
Photochemical oxidants	1 hr	0.08 ppm[a] (160 $\mu g/m^3$)	Same as primary standards
Nitrogen dioxide	Annual	0.05 ppm (100 $\mu g/m^3$)	Same as primary standards
Particulate	Annual geometric Mean	75 $\mu g/m^3$	60 $\mu g/m^3$
	24 hrs	260 $\mu g/m^3$	150 $\mu g/m$
Sulfur dioxide	Annual arithmetic Mean	0.03 ppm (80 $\mu g/m^3$)	0.02 ppm (53 $\mu g/m^3$)
	24 hrs	0.14 ppm (373 $\mu g/m^3$)	. . .
	3 hrs	. . .	0.50 ppm (1334 $\mu g/m^3$)

[a] Not to be exceed more than one per year.

ppm -parts per million
mg/m^3-milligrams per cubic meter
$\mu g/m^3$-micrograms per cubic meter

Table 2-3.
EFFECTS OF AIR POLLUTION

A. Biological Effects on Human Subjects

Pollutant	Effect	Single concentration	Average concentration	Exposure	Other	Reference
Carbon monoxide	Epidemiological significance	30 ppm		8 hours	Synergistic in PO_2 depression	4
	Discomfort	900 ppm	900 ppm	1 hour		3
		100 ppm	100 ppm	9 hours		3
	Severe distress	100 ppm	100 ppm	15 hours		3
	Lethal	4 000 ppm		<1 hour		
Hydrocarbons					HC + O_3 → tumorigen	
Inorganic particulates	Pulmonary sclerosis					
Nitrogen dioxide	Lethal Mild accelerator of lung tumors	500 ppm	500 ppm	48 hours	NO_2 + micro-organisms (pneumonia) + HNO_3 (bronchiolitis, fibrosa obliterans) + tars (smokers, lung cancer)	1

Table 2-3.

EFFECTS OF AIR POLLUTION (Continued)

Pollutant	Effect	Single concentration	Average concentration	Exposure	Other	Reference
Ozone	Odor	<0.02–0.05 ppm		Instantaneous	Accelerated aging	6,7
	Pulmonary function		0.60–0.80 ppm	120 minutes	Reduction in steady state pulmonary diffusing capacity (DL_{co})	8
	Discomfort		0.05–0.10 ppm	13–30 minutes		6,7
	Mucosa		0.30–1.00 ppm	15–60 minutes	O_3 + microorganisms (lung-tumor accelerator)	6,9
	Severe distress		1.5–2.0 ppm	120 minutes	Impaired lung function: severe fatigue, chest pains; coughing for 2 weeks	10
	Histological		0.2–0.25 ppm	30 minutes	Sphering of red blood cells	11
	Other		0.60–0.80 ppm	120 minutes	Substernal soreness and tracheal irritation 6–12 hours after exposure, disappearing within 24 hours	8

Table 2-3.
EFFECTS OF AIR POLLUTION (Continued)

Pollutant	Effect	Single concentration	Average concentration	Exposure	Other	Reference
PAN[a]	Pulmonary function	>0.30 ppm		5 minutes	Significant increase in oxygen uptake during light exercise	12
Sulfur dioxide, sulfur trioxide	Odor	0.5–0.7 ppm		1 second		13
	Taste	0.3–0.1 ppm		A few seconds		13
	Epidemiological significance	0.20 ppm	0.015 ppm	24 hours (annual average)		13
	Pulmonary function	1.6 ppm		10 minutes	SO_2, SO_3 + particulates aggravate lung disease	13
	Discomfort	5 ppm		10 minutes (sensitive subjects)		13
	Severe distress	5–10 ppm				
Total oxidant	Pulmonary function		0.138 (mean of daily maxima NKI)	1 week	b	14

Table 2-3.
EFFECTS OF AIR POLLUTION (Continued)

Pollutant	Effect	Single concentration	Average concentration	Exposure	Other	Reference
Suspended particulate and settleable matter	Epidemiological significance		500 $\mu g/m^3$	24 hours	In presence of 24-hour August SO_2 concentration of 0.15 ppm	18,19
Suspended particulate and settleable matter (Cont.)	Discomfort		≥150 mg/m^3 1.5 mg/cm^3	24 hours 30 days	Continuous source, dustfall	20
	Other				Particles <5 μm and concentration >10 particles/cm^3 do not have complete elimination from lungs	21

Table 2-3.
EFFECTS OF AIR POLLUTION (Continued)

B. Biological Effects on Animals

Pollutant	Effect	Subject	Single concentration	Average concentration	Time of average	Other	Reference
Nitrogen dioxide	Odor		5 ppm		5 seconds		2
	Discomfort	Mice, rabbits, cats	10–20 ppm				2
	Mucosa	Mice, rabbits, cats	10–20 ppm				2
	Severe distress	Mice, rabbits, cats	20–100 ppm				2
	Pathological	Mice	8 ppm	8 ppm	8 weeks		3
	Lethal	Man	500 ppm	500 ppm	48 hours		1
Nitrogen oxide	Lethal	Mice	2 500 ppm		6–7 minutes		2
		Mice	320 ppm		60 minutes		4
PAN[a]	Lethal	Mouse		105 ppm	120 minutes		5
Sulfur dioxide	Lethal	Rabbit		50 ppm	30 days/6 hour day		6
	Central nervous system	Animal	0.20 ppm		10 seconds several times		6
Total oxidant	Other	Animals		1 000 ppm	8–16 hours	100% kill	6
	Histological	Mouse		>0.40 ppm (NKI)	2–3 hours		7
	Pathological	Mouse		0.40 (mean of daily maxima NKI)	16 months		8

Table 2-3.

EFFECTS OF AIR POLLUTION (Continued)

C. Biological Effects on Vegetation

Pollutant	Subject	Effect	Single concentration	Average concentration	Time of average	Other	Reference
Nitrogen dioxide	Plants	Plant leaf symptoms	3 ppm	2.5	4 hours	Symptoms similar to SO_2. Irregular, white, or brown collapsed lesion on intercostal tissue and near leaf margin	9, 10
Ozone	Plants	Palisade of leaf is affected. Growth suppression and changes in pigmentation, such as flecks, stippling, bleaching, and bleached spotting, occur. There is early abscission, and conifer needles become brown and necrotic. Time, 4 hours; concentration, 0.03 ppm. See References 11-21					
Peroxyacetyl nitrate (PAN)	Plants	Spongy cells of leaves are affected. Glazing, silvering, or bronzing occurs on the lower leaf surface. Time, 6 hours; average concentration, 0.01 ppm. See References 20, 21, 23, and 24					
Sulfur dioxide		Plant leaf symptoms		0.28 ppm	24 hours	Bleached spots, bleached areas between veins, bleached margin	10, 26
		Plant chlorosis	>0.25 ppm	0.03 ppm	Annual average		10, 26
		Plant growth altered		0.05–0.20 ppm	24 hours; for	Growth suppression, early	10, 26

Table 2-3.
EFFECTS OF AIR POLLUTION (Continued)

Pollutant	Subject	Effect	Single concentration	Average concentration	Time of average	Other	Reference
					growing season	abscission, reduction in yield	
Total oxidant	Plants	See References 11, 14–16, 27				Affects mesophyll cells	

REFERENCES

1. *Air Pollution*, A.C. Stern, Ed., Vol. 1, Academic Press, New York, N.Y., 1962.
2. *Occupational Diseases*, U.S. Public Health Service Publication 1097, p. 51.
3. F.A. Patty, *Industrial Hygiene and Toxicology*, Vol. 2, John Wiley & Sons, New York, N.Y., 1962.
4. *California Standards for Ambient Air Quality and Motor Vehicle Emissions*, Department of Public Health, Bureau of Air Sanitation, 1964.
5. E.J. Largent, *Fluorosis*, Ohio State University Press, 1961.
6. A. Henschler *et al.*, *Archiv für Gewerbepatholgie und Gewerbehygiene*, *17*:547, 1960.
7. W.W. Witheridge and C.P. Yaglou, *J. Amer. Soc. Heat. Vent. Eng.*, *45*:509, 1939.
8. W.A. Young, D.B. Shaw, and D.V. Bates, *J. Appl. Physiol.*, *19*:765, 1964.
9. S. Wilska, *Acta Chem. Scand.*, *5*:359, 1951.
10. S.S. Griswold, L.A. Chambers, and H.L. Motley, *Arch. Ind. Health*, *15*:108, 1957.
11. R. Brinkman, H.B. Lamberts, and T.S. Veninga, *Lancet*, *7325*:133, January [illegible], 1964.
12. L.E. Smith, *Arch. Environ. Health*, *10*:161, February 1965.
13. *Air Quality Criteria for Sulfur Oxides*, U.S. Public Health Service Publication 1619, 1967.
14. J.E. Remmers and O.J. Balchum, Paper 65-43, Presented at the 58th Annual Meeting of the Air Pollution Control Association, June, 1965, Toronto, Canada.
15. K.A. Bushtueva, in *Limits of Allowable Concentrations of Atmospheric Pollutants*, V.A. Rayatonov, Ed., Book 3, U.S. Department of Commerce, Washington, D.C., 1957.
16. M.O. Amdur, L. Silverman, and P. Drinker, *AMA Arch. Ind. Hyg. Occup. Med.*, *16*:305, 1952.
17. M.O. Amdur *et al.*, *Ann. Occup. Hyg.*, *3*: 71, 1961.
18. A.F. Martin, *Proc. Roy. Soc. Med.* (London), *57*:969, 1964.
19. J.L. Burn and J. Pemberton, *Int. J. Air Water Pollut.* (London), *7*:5, 1963.
20. *To Control Local Air Pollution from Sources of Particulate or Gaseous Matter Emissions*, Regulation IV, Commonwealth of Pennsylvania, Department of Health, Harrisburg, Pa., Adopted March 15, 1966.
21. C.N. Davis, *Brit. Med. Bull.*, *19*:49, 1963.

Table 2-4.

VISUAL RANGE IN A POLLUTED ATMOSPHERE

Relation Between Equivalent Visual Range and Particle Concentration

Mass concentration, $\mu g/m^3$	Scattering coefficient due to aerosol, b_{scat}/m	Equivalent visual range, km	Equivalent visual range, miles
10	0.3×10^{-4}	120.0	75.00
30	1.0×10^{-4}	40.0	25.00
100	3.3×10^{-4}	12.0	7.50
300	10.0×10^{-4}	4.0	2.50
1 000	33.0×10^{-4}	1.2	0.75

Note: These experimental data are in substantial agreement with other reported measurements; see *Air Quality Criteria for Particulate Matter*, AP-49, National Air Pollution Control Administration, January 1969.

Source: R. J. Charlson, "Atmospheric Aerosol Research at the University of Washington," *J. Air Pollut. Contr. Assn.*, *18*:652, 1968.

Table 2-5.

AIR POLLUTION DAMAGE TO VARIOUS MATERIALS

Materials	Typical manifestation	Measurement	Principal air pollutant	Other environmental factors
Metals	Spoilage of surface, loss of metal, tarnishing	Weight gain of corrosion products, weight loss after removal of corrosion products, reduced physical strength, changed reflectivity or conductivity	SO_2, acid gases	Moisture, temperature
Building materials	Discoloration, leaching	Not usually measured quantitatively	SO_2, acid gases, sticky particulates	Moisture, freezing
Paint	Discoloration, softened finish	Not usually measured quantitatively	SO_2, H_2S, sticky particulates	Moisture, fungus
Leather	Powdered surface, weakening	Observation, loss of tensile strength	SO_2, acid gases	Physcial wear
Paper	Embrittlement	Decreased folding resistance	SO_2, acid gases	Sunlight
Textiles	Reduced tensile strength, spotting	Reduced tensile strength, altered fluidity	SO_2, acid gases	Moisture, sunlight, fungus
Dyes	Fading	Fading by reflectance measurements	NO_2, oxidants, SO_2	Sunlight, moisture
Rubber	Cracking, weakening	Loss in elasticity, increase in depth of cracks when under tension	Oxidants, O_3	Sunlight
Ceramics	Changed surface appearance	Changed reflectance measurements	Acid gases	Moisture

Source: J.E. Yocom and R.O. McCaldin, in *Air Pollution*, A. C. Stern, Ed., Vol. 1, Academic Press, New York, N.Y., 1968, p. 624.

Table 2-6.
ADDED COSTS OF LIVING IN DIRTY ENVIRONMENT

Downtown Steubenville, Ohio, 383 $\mu g/m^3$
Versus Uniontown, Pa., 115 $\mu g/m^3$
Particulates for 28 Activities, 1960

	Income group[a]	Extra cost per family	
		Do-it-yourself	Non-do-it-yourself
Inside maintenance	A	$ 29	$162
	B	44	227
Outside maintenance	A	21	49
	B	337	368
Laundry and cleaning	A	27	79
	B	129	186
Hair and facial care		9	48
Totals, per family			
In private homes	A	86	338
	B	519	829
In apartments (no inside painting or decorating, no outside maintenance)	A	47	263
	B	158	423

[a] A–Annual income under $8 000.
B–Annual income, $8 000 or more.

Source: *Interstate Air Pollution Study*, U.S. Department of Health, Education, and Welfare, Robert A. Taft Sanitary Engineering Center, Cincinnati, O., 1966.

Shelby, Hamilton, and Knox Counties (Figure 2-1). Ozone levels of these counties have exceeded their national standard. As to CO, only three counties (i.e.; Shelby, Davidson, and Knox) have been designated as nonattainment areas (Figure 2-2). All counties in Tennessee have retained their attainment status relative to NO_2 standard (Ref. 52).

2.3 CLEAN AIR ACT AMENDMENTS (CAAA) REQUIREMENTS FOR I/M PROGRAM

The passage of the 1977 Amendments to the Clean Air Act has brought about a number of new requirements for the control of air pollutant emissions from automobiles. Among the most important of these requirements is the idea that vehicles should maintain their lowest feasible emission levels throughout their lifetime. To attain this goal, the Act now specifies provisions for motor vehicle emission I/M programs. The purpose of this technical memorandum is to summarize the specifications of the CAAA with regard to I/M and forecast the implications of these specifications on the planning duties of the relevant environmental protection agencies.

2.3.1 CAAA Requirements

The CAAA include many specifications for the revision of State Implementation Plans (SIPs) and, in particular, call for the inclusion of transportation control measures which are necessary to attain and maintain NAAQS. Motor vehicle I/M programs have been shown to provide important emission reduction benefits and, hence, deserve attention as a potential transportation emission control measure for many areas throughout the country. This potential is recognized in the CAAA. Section 108 of the Act was amended to require the EPA to publish information regarding processes, procedures, and methods for implementing I/M programs. The EPA has fulfilled this charter through the publication of "Information Document on Automobile Emissions Inspection and Maintenance Programs" (Ref. 18).

More significant, perhaps, are the CAAA requirements for nonattainment areas and their inclusion in SIPs. Each state in which there are any

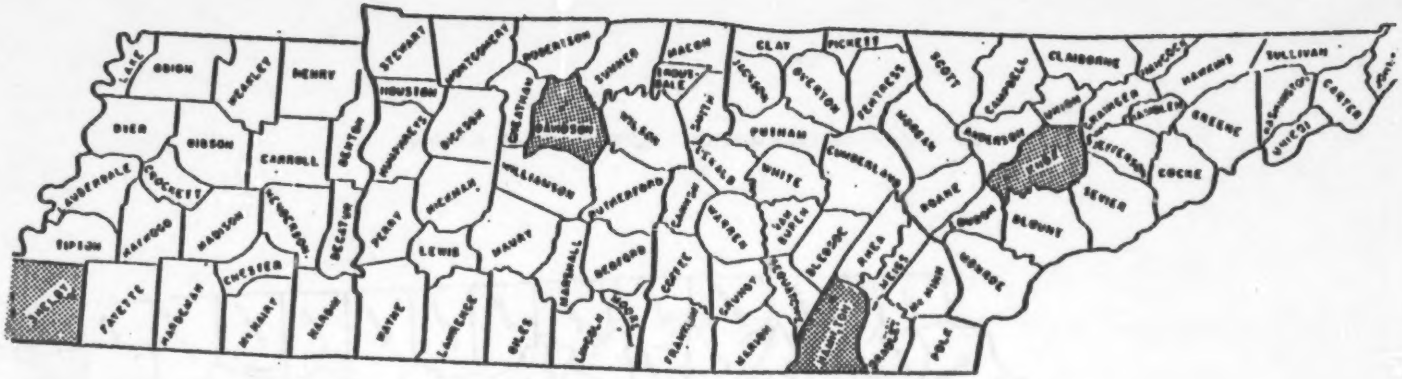

LAKE
OBION
WEAKLEY
HENRY
STEWART
MONTGOMERY
ROBERTSON
SUMNER
MACON
CLAY
PICKETT
SCOTT
CAMPBELL
CLAIBORNE
HANCOCK
HAWKINS
SULLIVAN
JOHNSON
DYER
GIBSON
CARROLL
BENTON
HOUSTON
HUMPHREYS
DICKSON
CHEATHAM
DAVIDSON
WILSON
TROUSDALE
SMITH
JACKSON
OVERTON
FENTRESS
MORGAN
ANDERSON
UNION
GRAINGER
HAMBLEN
GREENE
WASHINGTON
CARTER
UNICOI
LAUDERDALE
CROCKETT
TIPTON
HAYWOOD
MADISON
HENDERSON
DECATUR
PERRY
HICKMAN
WILLIAMSON
RUTHERFORD
DE KALB
PUTNAM
WHITE
CUMBERLAND
ROANE
KNOX
JEFFERSON
COCKE
SEVIER
BLOUNT
LOUDON
SHELBY
FAYETTE
HARDEMAN
CHESTER
MC NAIRY
HARDIN
WAYNE
LEWIS
MAURY
LAWRENCE
GILES
MARSHALL
LINCOLN
MOORE
BEDFORD
COFFEE
CANNON
WARREN
VAN BUREN
FRANKLIN
GRUNDY
SEQUATCHIE
BLEDSOE
RHEA
MEIGS
MARION
HAMILTON
BRADLEY
MC MINN
MONROE
POLE

Figure 2-1. TENNESSEE COUNTIES NONATTAINMENT FOR OZONE

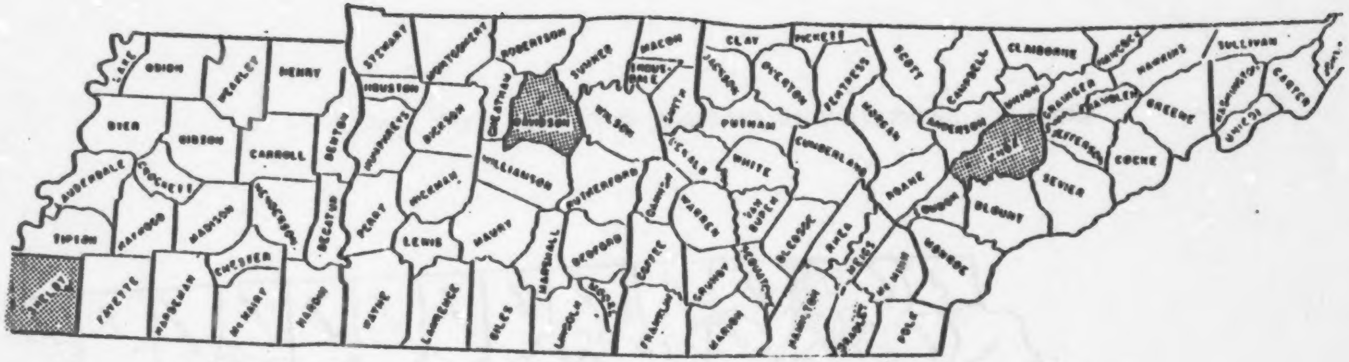

LAKE
OBION
WEAKLEY
HENRY
STEWART
MONTGOMERY
ROBERTSON
SUMNER
MACON
TROUSDALE
CLAY
PICKETT
SCOTT
CAMPBELL
CLAIBORNE
HANCOCK
HAWKINS
SULLIVAN
DYER
GIBSON
CARROLL
BENTON
HOUSTON
HUMPHREYS
DICKSON
CHEATHAM
DAVIDSON
WILSON
SMITH
JACKSON
OVERTON
FENTRESS
PUTNAM
MORGAN
ANDERSON
UNION
GRAINGER
HAMBLEN
GREENE
WASHINGTON
CARTER
UNICOI
JOHNSON
LAUDERDALE
CROCKETT
TIPTON
HAYWOOD
MADISON
HENDERSON
DECATUR
PERRY
HICKMAN
WILLIAMSON
RUTHERFORD
DE KALB
WHITE
CUMBERLAND
ROANE
KNOX
JEFFERSON
COCKE
SEVIER
BLOUNT
LOUDON
LEWIS
MAURY
CANNON
WARREN
VAN BUREN
BLEDSOE
RHEA
MEIGS
MONROE
SHELBY
FAYETTE
HARDEMAN
CHESTER
MC NAIRY
HARDIN
WAYNE
LAWRENCE
GILES
MARSHALL
BEDFORD
LINCOLN
MOORE
COFFEE
FRANKLIN
GRUNDY
SEQUATCHIE
MARION
HAMILTON
BRADLEY
MC MINN
POLK

Figure 2-2. NONATTAINMENT COUNTIES FOR CO

nonattainment areas must submit a revised SIP by December 31, 1979 which provides for attainment of ambient air quality standards by December 31, 1982. In areas which demonstrate that the standards for oxidant or CO cannot be met by December 31, 1982, an extension to December 31, 1987 can be granted. Two of the many requirements for this extension are that an updated SIP revision must be submitted before July 1, 1982, and that a specific schedule for implementation of an I/M program be established. The EPA has also established the general requirements for I/M programs in a February 24, 1978 memorandum from the EPA Administrator to the Regional Administrators (reprinted in the Federal Register on May 19, 1978, 43 F.R. 21673).

In producing an I/M SIP revision, states must provide for:

1. An analysis of the benefits and costs of the program,
2. A public information effort,
3. A legislative proposal, and
4. A schedule for I/M implementation.

Before January 1, 1979, an SIP revision must be adopted by the state air pollution control board or agency head, as appropriate. As a part of the SIP revision submittal itself, there must be a commitment by the Governor to implement the I/M program according to the schedule submitted. The schedule is as follows, quoting from Ref. 55.

> "Normally, adequate legal authority to implement a SIP revision must exist for a revision to be approved. Where a legislature has had adequate opportunity to adopt enabling legislation before January 1, 1979, the Regional Administrator should require certification that adequate legal authority exists for I/M implementation by January 1, 1979. However, for many states there will be insufficient opportunity to obtain adequate legal authority before their legislatures meet in early 1979. Therefore, a certification of legal authority for the implementation in these states must be made no later than June 30, 1979. An extension to July 1, 1980, is possible, but only when the state can demonstrate that a) there was insufficient opportunity to conduct necessary technical analyses and/or b) the legislature has had no opportunity to consider any necessary enabling legislation for inspection/maintenance between enactment of the 1977 Amendments to the Act and June 30, 1979. Certification of adequate legal authority, or other evidence that legal authority has been adopted, must be submitted to the EPA Regional Offices to be included in the SIP revision already submitted. Failure to submit evidence of legal authority by the appropriate deadline will constitute a failure to submit an essential element of the SIP, under Sections 110(a)(2)(I) and 176(a) of the Act."

"Prior to the respective deadlines for initiating mandatory inspection and mandatory repair of failed vehicles, the state, local government, or regional agency should adopt whatever legally enforceable requirements are necessary to ensure that vehicles are not used unless they comply with the inspection/ maintenance requirements. Written evidence of adoption of these requirements should be submitted to the EPA Regional Offices, to be included in the SIP revision already submitted by January 1, 1979."

Quoting further, etc.

"Implementation of I/M 'as expeditiously as practicable' shall be defined as implementation of mandatory repair for failed vehicles no later than 2-1/2 years after passage of needed legislation or certification of adequate legal authority for new centralized systems (State- or contractor-operated) and 1-1/2 years after legislation or certification for decentralized systems (private garage-operated) or for centralized systems which are adding emission inspections to safety inspections. For the normal legislation deadline of June 30, 1979, new centralized programs must start by December 31, 1981, and all others must start by December 31, 1980. For the case of the latest possible legislation date, July 1, 1980, this means that a new centralized program must start by December 31, 1982, while all other programs must start by December 31, 1981. Where I/M can be implemented more expeditiously, it must be. Each state implementation schedule must be looked at individually to determine if it is as expeditious as practicable. Implementation dates ordered by courts, if earlier than these dates, take precedence. (see Appendix A)."

The Emission Control System Performance Warranty contained in Section 207(b) of the Clean Air Act provides warranty coverage to motorists in areas having an I/M program. The Emission Performance Warranty, upon promulgation of regulation by the EPA, will require the automobile manufacturer to bear the cost of repair of any properly maintained and operated vehicle which fails an EPA established emissions test within 24 months or 24,000 miles, whichever occurs first, of the original sale to the ultimate purchaser. After this period, the warranty applies only to catalytic converters, thermal reactors, or other components installed on or in a vehicle for the sole or primary purpose of reducing vehicle emissions.

The CAAA extended the coverage of Section 203 of the Clean Air Act to prohibit the removal of, or tampering with, emission control equipment by independent auto repair operators. Civil penalties of $2,500 for such actions were also established.

2.3.2 Potential EPA Sanctions

There are sanctions for noncompliance with I/M requirements such that a state will lose its highway funds (except for transit-, safety-, or air quality-related transportation projects) if the Governor has not submitted an SIP revision by July 1, 1979, or that reasonable efforts toward submitting such an SIP are not being made (this also applies to the 1982 SIP revision). If state or local governments are not implementing an SIP, they cannot receive any grants under the Act. There is a requirement for Federal agencies not to take any action including making any grant that does not conform to an approved SIP, nor can any transportation planning agency give approval to anything which does not conform to the SIP. Priority must be given for programs with air quality-related transportation consequences to the implementation of SIPs necessary to achieve and maintain air quality standards.

2.4 I/M PROGRAM EFFECTIVENESS IN REDUCING HYDROCARBON AND CARBON MONOXIDE EMISSIONS FROM LIGHT-DUTY VEHICLES

Inspection and maintenance of light-duty vehicles has been shown to produce significant reductions in emissions of CO and HC. Since mobile sources are usually the major contributors to CO and HC emissions in an urban area, the emission reductions produced by an I/M program can be translated into beneficial improvements in the region's air quality.

2.4.1 Emission Reduction Potential

The potential benefits which can result from an I/M program depend on a number of factors. The most important of these factors deals with I/M emission standards, or "cut points." The cut point is the level of emissions which distinguishes between those vehicles requiring emissions-related maintenance and those that do not. The cut points that are selected define a "stringency factor" which is a measure of the rigor of the program based on the estimated fraction of the vehicle population whose emissions would exceed cut points for either or both CO and HC. There are two basic concerns that constrain the selection of I/M emission standards. As mentioned previously, the I/M emission standards determine the emission reduction potential. As such, I/M standards or cut points should be set to achieve a desired emission reduction. On the other end, the cut point should be limited to a level that will be acceptable to both the general public and the repair industry. As experienced by other programs, negative public sentiments may result if an excessive volume of vehicles do not comply with I/M standards at first inspection. Further difficulties will arise if the total of the noncomplying vehicles exceed the available capacity of the repair industry. The necessary vehicle maintenance will be compromised under these conditions. Cut points must be set at a level where potential emission reduction benefits are maximized while impacts to the public are minimized. Detailed discussion of the stringency factor is given in Appendix B.

The air quality benefit from an I/M program is also dependent, in part, on the ability of the service industry to properly perform the repair work necessary to lower emissions. Depending on the level of service industry training, emissions could be reduced just to the levels which would pass the I/M test or well below them. Some savings in repair costs may also result from the training since the mechanics would be familiar with the problems and the best solutions.

The total emission reductions that result from the program are directly dependent on the number and types of vehicles inspected and the requirement that maintenance be performed. I/M programs are generally designed around automobiles and other light-duty vehicles; however, motorcycles and heavy-duty trucks can also be included to provide additional emission reductions. In some cases, it may be desirable not to require repairs on old cars when the repair work would cost a major percentage of the car's value.

Frequency of testing also can affect the emission benefit scenario. Most existing I/M programs require annual inspection. This frequency is justified on the basis that it minimizes costs and maximizes public acceptance while maintaining a reasonably high level of emission reduction. A semi-annual program would involve substantially higher program costs arising from the need for a greater number of inspection lanes, as compared to an annual inspection program. Semi-annual inspections may be justified for higher usage vehicles, such as taxis, however. A bi-annual program, while certainly providing some emission benefits, will lose some of the effectiveness of an annual program because cars are allowed to deteriorate to a higher level.

The definitive statement on potential emission reductions from an I/M program appears in the Code of Federal Regulation under the title of "Appendix N--Emissions Reductions Achievable Through Inspection, Maintenance of Light-Duty Vehicles, Motorcycles, and Light- and Heavy-Duty Trucks" (see Appendix C).

2.4.2 Results of California Study

The California Air Resources Board (ARB) has conducted a number of study efforts to determine the emission-reduction potential of various I/M programs.

In May of 1976, results of these studies were published. The results of these studies indicated that those vehicles which were repaired under the idle I/M regime achieved immediate reductions of 38 percent in HC emissions and 33 percent in CO emission (see Tables 2-7 and 2-8). When these reductions are deteriorated over 1 year's time and distributed over the total vehicle population, the reductions are 9 percent HC and 8 percent CO.

These results generally agree with those obtained in other studies performed by and for the U.S. EPA and the ARB (see Table 2-9).

Table 2-9. COMPARISON OF EMISSIONS AND FUEL CONSUMPTIONS REDUCTIONS AND REPAIR COSTS WITH OTHER STUDIES

	IMMEDIATE REDUCTIONS - FAILED VEHICLES				ASSUMED
IDLE REGIME	HC	CO	NO_x	Fuel Consumption	FAILURE RATE
California Study (Ref. 3)	38%	33%	4.2%	3.8%	35%
Northrop (Ref. 19)	40%	37%	-13%	-	50%
EPA (Ref. 41)	42%	34%	5.0%	-	50%
Olson (Ref. 21)	38%	29%	-7.3%	3.0%	50%

A study made by the Northrop Corporation for the ARB in 1971 showed emissions reductions comparable to those in this study while using a 50 percent failure rate.

Table 2-7. HYDROCARBONS EMISSION REDUCTION (IDLE REGIME)

VEHICLE STATUS	AVERAGE IDLE REGIME
A. Without Deterioration:	
Pass*	4.02
Fail (before repair)**	7.21
Fail (after repair)**	4.46
Immediate Reduction	2.75
% Decrease (failed vehicles)	38.19
Total Population	
Without MVIP	5.14
With MVIP	4.17
% Decrease	18.76
B. With Deterioration:	
Total Population	
Without MVIP	5.14
With MVIP	4.66
% Decrease	9.38

*Passed all standards.
**Failed one or more standards.

Table 2-8. CARBON MONOXIDE EMISSION REDUCTION (IDLE REGIME)

VEHICLE STATUS	AVERAGE IDLE REGIME
A. Without Deterioration:	
Pass*	41.69
Fail (before repair)**	65.42
Fail (after repair)**	43.94
Immediate Reduction	21.48
% Decrease (failed vehicles)	32.84
Total Population	
Without MVIP	49.99
With MVIP	42.47
% Decrease	15.04
B. With Deterioration:	
Total Population	
Without MVIP	49.99
With MVIP	46.23
% Decrease	7.53

*Passed all standards.
**Failed one or more standards.

2.5 TECHNICAL MEMORANDUM COMPARING LOADED-MODE AND IDLE-MODE TESTING TECHNIQUES AS TO RELATIVE COSTS AND BENEFITS

2.5.1 Introduction

The purpose of this memorandum is to supply technical information on the relative costs and benefits associated with idle- and loaded-mode testing techniques for vehicle I/M programs. The information has been assembled from previously operated I/M programs in other areas of the country and is intended to provide generalized comparative data between the two methodologies. The results of the comparison can be briefly summarized as follows:

- Achieveable reductions of HC and CO emissions from the vehicle fleet are equivalent for both modes of testing.
- Achievable reductions of NO_x are only realized when using loaded-mode testing.
- Fuel economy improvements are equivalent for both methods.
- Investment costs required for implementation of loaded-mode are typically 57 percent higher than costs for idle-mode.
- Operating costs required for loaded-mode testing are typically 20 percent higher than costs for idle-mode.
- Inspection fees paid by the consumer are approximately 30 percent higher at loaded-mode testing facilities than at idle-mode stations.
- Average repair costs paid by the consumer to meet inspection standards are equivalent for both testing methods.
- Loaded-mode testing fails a higher percentage of vehicles with malfunctioning emission control components and provides more specific diagnostic information for correction of these malfunctions.

The remainder of this memorandum addresses the technical differences between the two methods, gives typical benefits and costs which can be expected of them and presents a summary of a benefit/cost comparison.

This memorandum also presents cost-scaling factors associated with the testing methods for three I/M administrative approaches--State-operated, contractor-operated, and private garage-operated test stations. In addition, the California ARB I/M study was reviewed for the comparison of different effects of an idle test mode program and a loaded test mode program.

2.5.2 Technical Evaluation

2.5.2.1 Idle Inspection Test Mode

In this inspection and test regime, the tested vehicle is operated until proper engine temperature is achieved. While the vehicle is operating at idle, a sample of the exhaust is analyzed for HC and CO concentration in the gas analyzers, and the results are recorded. If the vehicle does not pass the established emission limits, the vehicle is required to receive corrective action.

The term "idle inspection" is somewhat misleading since the vehicle is also operated at higher rpm (2,500) as part of the inspection test cycle. The test mode is more accurately described as a static or light-load test, as the vehicle engine is operated without benefit of vehicle road loads. The sensitivity of idle testing is improved by performing this additional testing at higher engine speeds. The engine loads experienced during higher rpm operations provide an opportunity to measure effectiveness of off-idle carburetor circuits and to detect additional malfunctions that may contribute to high emissions. During the idle test procedure, engine operations and emission measurements are accomplished at 2,500 rpm prior to performing idle measurements. This sequence provides the opportunity for engine temperature stabilization.

The following is a description of a typical idle test sequence and diagnostic information when the vehicle fails:

A. Pre-Test

Prepare vehicle and equipment for test.

1. Test Equipment - Service, warm up, and calibrate HC/CO test equipment per manufacturer's specifications.

2. Test Vehicle - Verify engine is at normal operating temperature (warm up as required).

3. Hook-Up - Insert probe in exhaust pipe (driver's side if dual exhaust), hook up tachometer per manufacturer's instructions.

B. Test

Perform HC/CO and rpm measurements and compare to idle test standards.

1. High rpm - Run engine at high rpm for 60 seconds to burn out carbon.

2. Idle rpm - Operate engine at idle rpm.

3. High-Idle - Operate engine in neutral at 2,500 rpm, record HC/CO measurements.

4. Idle rpm - Operate engine at idle rpm (in drive if automatic transmission), record HC/CO measurements.

C. Diagnostic Information

1. High HC - Indications are caused by ignition misfires, advanced ignition timing, exhaust valve leakage, and over-lean mixtures. Ignition misfires can be diagnosed by use of the oscilloscope; timing problems by use of timing light. Valve failure is indicated by cylinder balance testing with compression test verification. Lean misfire is caused by too lean idle mixture setting or manifold vacuum leaks.

2. High CO - This condition can be caused by abnormally restricted air cleaner, stuck or partially closed choke or carburetor idle circuit failure. Rough or erratic idle can be caused by PCV valve malfunction.

3. Idle HC/CO - Failure/malfunction truth tables can be used as a guide to identifying failures (see Table 2-10).

2.5.2.2 Loaded Cycle Test Mode

The loaded-cycle test mode is the measurement of exhaust emissions with the vehicle in a forward drive gear and operating at simulated driving conditions. Pollutants are measured at various test conditions as specified by a testing procedure. One type of loaded testing technique is based on experimentally derived data which indicates that unnecessarily high emissions are caused by specific maladjustments or malfunctions. When these deficiencies are corrected, the emission characteristics of the vehicle engine are as good as can be obtained by the repair facility. The technique was developed by determining the minimum number and variety of operating modes required to expose these deficiencies and defects.

Key-mode testing is a test process that was developed by the Clayton Manufacturing Company. The test is performed on a simple chassis dynamometer at vehicle speed and load modes that are calculated to expose engine faults. After vehicle pretest activities are performed, the vehicle is positioned on the dynamometer and emission test equipment attached. The initial test mode is at high-cruise conditions. The driver accelerates to a speed and load range of 44 to 50 mph and 21 to 30 hp, depending upon vehicle weight. During this period, the engine temperature is stabilized. High-cruise emission measurements are performed and the vehicle speed and load is reduced to 22 to 30 mph and 6 to 12 hp, depending again upon vehicle weight. After measurement, the vehicle is allowed to return to idle for final measurements prior to post-test operations.

A set of repair aids has been developed by Clayton in the form of truth tables. The tables, when used as an inspection aid, provide diagnostic

Table 2-10. MALFUNCTION TRUTH TABLE FOR IDLE TESTING

Malfunction	HC		CO		Rough Idle
	High	Very High	High	Very High	
PCV Valve Dirty/ Restricted			X		X
Air Cleaner Dirty/ Restricted			X	X	
Choke Stuck Partially Closed				X	
Carburetor Idle Circuit Malfunction	X		X		X
Intake Manifold Leak	X	X			X
Ignition Timing Advanced	X				
Leaky Exhaust Valves	X	X			X
Ignition System Misfire	X	X			X

information to the repair station. In addition to the truth tables, a manual containing examples is provided to the repair facility.

The following is a description of a typical key-mode test sequence with diagnostic information derived from failed vehicle tests.

A. Pre-Test

Prepare vehicle and equipment for test.

1. Test Equipment - Calibrate HC/CO test equipment per manufacturer's specification.

2. Test Vehicle - Verify engine is at normal operating temperature.

3. Hook-Up - Position vehicle on dynamometer, identify proper load settings, and insert probe in exhaust tail pipe.

B. Test

Perform HC/CO measurements and compare to test standards.

1. High Cruise - Operate vehicle at a speed and load range of 44 to 50 mph and 21 to 30 hp, depending upon vehicle weight. Record HC/CO measurement.

2. Low Cruise - Operate vehicle at 22 to 30 mph and 6 to 12 hp, depending upon vehicle weight. Record HC/CO measurements.

3. Idle - Operate engine at idle rpm and record HC/CO measurements.

C. Diagnostic Information

See Appendix D.

Another type of loaded-mode test procedure is the transient loaded-mode test. This test collects a composite emission sample from a specified driving schedule. The composite sample is collected into a Constant Volume Sampler

(CVS) unit for further analysis to determine pollutant concentration. Again, a chassis dynamometer loads the vehicle to simulate the desired driving schedule. However, for this test, the dynamometer must be capable of performing at variable inertia weights and road load settings. The driving schedule for the transient test simulates a portion of an urban driving cycle. Two acceptable cycles are the Composite New Jersey/New York test and the Federal Short-Cycle test. The Federal Short-Cycle is a nine-mode CVS test of 125-second duration while the New Jersey/New York Composite test is a six-mode CVS test requiring 75 seconds as specified below:

NEW JERSEY/NEW YORK COMPOSITE TEST

Mode	Time in Mode, Seconds
Idle	22
0 to 30 mph acceleration	15
30 mph cruise	15
30 to 10 mph deceleration	12
10 mph cruise	7
10 to 0 mph deceleration	4
	75

2.5.2.3 Test Accuracy

Two different techniques were used to evaluate the accuracy of the idle and loaded-mode inspection regimes in identifying gross emitters. Both techniques, which are described in Table 2-11 came to the same conclusion: less than 3 percent of the vehicles in each regime failed but should have passed; and 50 to 60 percent of the vehicles in each regime passed but had some malfunction which, if detected, would have resulted in a significant reduction in emissions. More stringent inspection standards would detect more gross emitters in either regime, but would also increase the likelihood of failing a vehicle which had no malfunctions. This is because the correlation between a vehicle's emissions and the condition of its engine, although very good, is not perfect. The loaded regime had slightly fewer errors of omission (passing cars which should have failed), and the same or slightly more errors of commission (failing cars which should have passed) than the idle-regime.

Table 2-11. SUMMARY OF ERRORS OF OMISSION AND COMMISSION BY REGIME

Basis	Errors of Omission[a]		Errors of Commission[b]	
	Idle	Loaded	Idle	Loaded
Engine Diagnosis[c]	54%	51%	0.2%	0.0%
Emissions Regression Analysis[d]	58%	48%	0.5%	2.6%

[a] Vehicles which passed standards but should have failed. (Percent of total population.)

[b] Vehicles which failed standards but should have passed. (Percent of total population.)

[c] Whether or not a vehicle should have failed is based on whether the California Air Resources Board (ARB) engine diagnosis detected any emission control components which were malfunctioning or maladjusted, excluding idle speed.

[d] Whether or not a vehicle should have failed is based on a statistical analysis of the emissions tests of failed vehicles. The emissions reduction due to repair was compared with the emissions before repair for each vehicle. A "pseudo-standard" was derived for each pollutant, which was the level of emissions before repair at which there was a 50/50 chance that the car's emissions would be increased by repairs. A vehicle whose initial emissions were below the "pseudo-standards" yet which failed the MVIP standards was considered to be an error of commission. A vehicle whose initial emissions were above the "pseudo-standards" yet which passed the standards was considered to be an error of omission.

Source: California Air Resources Board, "Evaluation of Mandatory Vehicle Inspection and Maintenance Programs," May 1976

2.5.2.4 Summary

Loaded-mode testing can give better indication of actual emissions since it simulates actual driving conditions, and provides better diagnostic information. Table 2-12 summarizes test procedure requirements for the specified test types. Testing lane configurations of these two test modes are presented in Table 2-13.

2.5.3 Benefits and Costs

2.5.3.1 Emission Reduction Benefits

The direct benefits of an I/M program are a reduction in air pollutant emissions and an increase in fuel economy. Implementation of an I/M program can potentially result in emission reductions for HC, CO, and NO_x. Potential emission reduction through an I/M program have been documented in Appendix N by the U.S. EPA. The text of Appendix N can be found in Part 51, Chapter 40, Code of Federal Regulations. A revised Appendix N has been proposed by U.S. EPA (Federal Register, May 2, 1977) and is included in this report as Appendix A. This proposed revision is expected to be promulgated in 1979.

Appendix N (Ref. 40) - In the revised Appendix N, I/M program effectiveness is given as a function of the level of technology, the stringency of emission standards, the length of program operation, and the adequacy of mechanic training.

Stringency of emission standards has a direct relationship with potential emission reduction. A stringency factor is defined as a measure of the rigor of a program based on the estimated fraction of the vehicle population whose emissions would exceed cut points for either or both CO and HC if there were no improvement in habits or maintenance quality to take place as a result of the program. Thus, a higher stringency factor that rejects more automobiles and, thereby, requires increased number of failed vehicles to be maintained, will result in more emission reduction. However, above 50 percent because of the lack of short test correlation to FTP and repair status for driveability,

Table 2-12. CHARACTERISTICS OF IDLE MODE AND LOADED MODE TESTING

Idle Mode Testing	Loaded Mode Steady-State Test	Loaded Mode Transient Test (CVS Tests)
1. Simple test procedure which requires minimum	1. Engine operated under simulated road cruise conditions	1. Engine operated under simulated urban driving cycle
2. Carburetor adjustments can be made during test	2. Includes an idle test which may not be equivalent to the idle mode testing sequence	2. Expected to provide closest correlation with FTP CVS emissions
3. Diagnosis of some engine maladjustments and malfunctions	3. Additional diagnostic information to repair facility	3. Variable inertial and power absorption dynamometer required
4. Can be duplicated by either public or private test systems	4. Requires dynamometers and other additional equipment	4. Driving cycle difficult to repeat accurately: cycles cannot be averaged
5. Requires minimal test time and equipment	5. Test cannot be duplicated in most repair facilities due to lack of dynamometer[a]	5. Test cannot be duplicated in most repair facilities
6. Malfunctions that occur under loaded conditions may not be detected	6. Requires more test time	6. Computer needed for rapid on-line data analysis; i.e., high initial costs

[a] Presently numerous commercial loaded mode tuning centers are being set up which could be a focal point for testing.

Source: Kincannon, B.F., and Castaline, A.H., "Information Documents on Automobile Emissions Inspection and Maintenance Programs - Final Report," EPA, Report 400/2-78-001, February 1978.

Table 2-13. TESTING LANE CONFIGURATIONS

TEST MODE	POSITION 1	POSITION 2	POSITION 3	DAILY OUTPUT[a]	ANNUAL OUTPUT
Idle Mode (plus tampering check for NO_x)					
1	All activities[b]			120	31,200
2	Check-in and test	Check-out		192	49,920
3	Check-in	Test	Check-out	320	83,200
Loaded Mode[c] (plus emission check for NO_x)					
1	All activities			106	27,560
2	Check-in and test	Check-out		160	41,600
3	Check-in	Test including NO_x emissions	Check-out	240	62,400

[a] 8-hour day.

[b] Activities are check-in, test, certification.

[c] Total time for loaded mode is 4.5 minutes, check-in 1 minute, test 2 minutes and 1.5 minute check-out.

NOTE: Test time is 90 seconds for idle-mode testing. Total time for all activities for idle-mode testing is 4 minutes. 1 minute check-in, 1.5 minute check-out.

Assumption: 1) 100 percent efficient

results in an increase of emissions (Ref. 35). In estimating the benefits attributable to programs with various stringency factors, the U.S. EPA has assumed that it is as important to fail a high Federal Test Procedure (FTP) CO emitter as a high FTP HC emitter.

The Appendix N also defines minimum requirements for an I/M program to be adopted by a State. Section of the Appendix N states that:

> "Basic program requirements. There are two basic types of operation which may be utilized for an I/M program, namely a centralized inspection system (government or contractor-operated) and a decentralized inspection system (private commercial garages). In order to obtain full emission reduction benefits for either a centralized or decentralized inspection system, certain minimum requirements are established, which if not met, will result in assessed emission reduction lower than those listed in Tables 1 through 5 of this Appendix.
>
> "a. Program requirements--Minimum for all programs.
> i. Provisions for regular periodic inspection (at least annually) of all vehicles for which emissions reductions are claimed.
> ii. Provisions to ensure that failed vehicles receive the maintenance necessary to achieve compliance with the inspection standards. The basic method is to require that failing vehicles pass a retest following maintenance.
> iii. Provisions for quality control. The reliability of the inspection system and equipment accuracy must be ensured. This will include routine maintenance, calibration and inspection of all I/M equipment, and routine auditing of inspection results.
>
> "b. Minimum decentralized program requirements. In order to receive the basic emission reduction benefits for a decentralized I/M program, the following requirements must be included in addition to provisions listed in Section 5(a).
> i. Provisions for the licensing of inspection facilities which insure that the facility has obtained, prior to licensing, analytical instrumentation which has been approved for use by the appropriate governing agency. A representative of the facility must have received instructions in the proper use of the instruments and in vehicle testing methods. The facility must agree to maintain records, to collect signatures of operators whose vehicles have passed inspection, and to submit to inspection of the facility.
> ii. Records required to be maintained should include the description (make, year, license number, etc.) of each vehicle inspected, and its emissions test results. Records must also be maintained on the calibration of testing equipment.
> iii. Copies of these inspection records should be submitted on a periodic basis to the governing agency for auditing.

iv. The governing agency should inspect each facility at least once every 90 days to check the facilities' records, check the calibration of the testing equipment and observe that proper test procedures are followed.

v. The governing agency should have an effective program of unannounced/unscheduled inspections both as a routine measure and as a complaint investigation measure. It is also recommended that such inspections be used to check the correlation of instrument readings among inspection facilities."

During the first year of an I/M program operation, the Appendix N credits allows certain percentage of reductions in HC and CO for stringency factors from 0.1 to 0.50 as noted in Table 2-14. Credits are applicable to both idle and loaded tests. Additive credits for subsequent years are indicated in Table 2-15.

Including mechanic training in an I/M program allows additional emission reduction credits. Tables 2-16 and 2-17 present emission reduction credits at different level of stringency factor.

Assuming nationwide average model-year mix and average distribution of vehicle miles traveled (VMT) by model-year, the U.S. EPA has also estimated basic emission reductions in 1987 for various types of annual I/M programs. These are tabulated in Table 2-18. As is indicated in the table, additional credits can be granted for mechanics training activities. The "with mechanic's training" credits are the maximum emission reduction credits allowable for I/M programs, but any credits beyond the basic credits must be specifically approved by the U.S. EPA.

2.5.3.2. Other I/M Benefits

An I/M program mandates all failed vehicles to be properly repaired. There is, therefore, potential fuel savings for motor vehicle owners. The amount of fuel saved by instituting mandatory vehicle procedures is a function of many variables. The following parameters are of particular importance: vehicle type, number of miles traveled per year, fuel economy (miles per gallon), stringency factor, etc. These variables are related in the following manner:

Table 2-14. FIRST YEAR OF PROGRAM CREDITS

	PERCENT			
	HC		CO	
STRINGENCY FACTOR	Technology I	Technology II	Technology I	Technology II
0.10	1	1	3	8
0.20	5	3	8	20
0.30	7	9	13	28
0.40	10	16	19	23
0.50	11	24	22	37

Table 2-15. SUBSEQUENT YEARS PROGRAM CREDIT

	ADDITIVE CREDIT	
NUMBER OF INSPECTIONS	HC (%)	CO (%)
2	7	8
3	14	15
4	20	19
5	25	23
6	30	27
7	33	30
8 or more	36	35

Table 2-16. MECHANIC TRAINING FIRST YEAR CREDITS

STRINGENCY FACTOR	TECHNOLOGY I		TECHNOLOGY II	
	HC (%)	CO (%)	HC (%)	CO (%)
0.10	1	5	3	7
0.20	3	7	5	10
0.30	4	9	4	10
0.40	6	8	1	7
0.50	7	7	1	5

Table 2-17. MECHANIC TRAINING SUBSEQUENT YEAR CREDITS

STRINGENCY FACTOR	TECHNOLOGY I			
	NUMBER OF INSPECTIONS			
	2		3 or more	
	HC (%)	CO (%)	HC (%)	CO (%)
0.10	3	3	15	18
0.20	4	8	10	15
0.30	6	5	9	9
0.40	5	5	5	5
0.50	3	2	3	2

STRINGENCY FACTOR	TECHNOLOGY II	
	NUMBER OF INSPECTIONS - 2 OR MORE	
	HC (%)	CO (%)
0.10	10	4
0.20	8	2
0.30	2	1
0.40	1	3
0.50	1	1

Table 2-18. LIGHT-DUTY VEHICLE EXHAUST EMISSION REDUCTIONS FROM INSPECTION/MAINTENANCE PROGRAMS AS OF DECEMBER 31, 1987

		BASIC PROGRAM		W/MECHANICS TRAINING[a,b]	
STRINGENCY FACTOR %	STARTING DATE[c]	CO (%)	HC (%)	CO (%)	HC (%)
10	07/01/80	22.7	26.0	46.8	42.5
	07/01/81	21.5	24.7	46.0	42.3
	07/01/82	19.6	22.6	43.2	39.0
	12/31/82	18.3	20.8	41.6	37.3
20	07/01/80	29.3	30.4	54.2	49.0
	07/01/81	27.9	28.7	52.0	47.2
	07/01/82	25.9	25.7	50.2	45.3
	12/31/82	24.5	23.9	48.8	43.6
30	07/01/80	34.0	33.6	57.7	52.1
	07/01/81	32.3	32.6	56.3	50.9
	07/01/82	30.4	30.0	54.5	49.3
	12/31/82	28.6	27.5	53.2	47.6
40	07/01/80	38.2	35.7	61.1	57.7
	07/01/81	36.6	34.2	59.8	54.3
	07/01/82	34.3	31.8	57.9	53.1
	12/31/82	32.8	30.0	56.5	51.2
50	07/01/80	41.4	36.8	62.5	57.2
	07/01/81	40.0	35.5	61.1	56.1
	07/01/82	37.9	32.9	59.3	54.3

NOTE: Policy guidance regarding the utilization of of I/M credits is due in November 1978.

[a] Assumptions:

1. All model years are included in the program.
2. Nationwide averages of vehicle mix by model year plus distribution of vehicle miles traveled by model year are assumed.

[b] Utilization of all or part of this credit or part of it can only be made with USEPA approval.

[c] Mandatory repair for failed vehicles is initiated on this date.

$$G_s = \left[(V_m/F_e) \times F_c \right] (T_v \times S_f)$$

where:

G_s = fuel gallons saved
V_m = mileage per vehicle traveled per year
F_e = fuel economy
F_c = increased fuel economy per failed vehicle
T_v = total vehicle population
S_f stringency factor

Preliminary study results indicate that fuel economy rate could be increased by 3 to 3.8 percent (Ref. 35). Various reports have indicated fuel savings from 0 to 12 percent. This depends upon the nature of the vehicle population and program requirements (Ref. 12, 36, 51).

Another possible benefit resulting from an I/M program could be the improvement of vehicle performance and the increase of vehicle life. The impact of I/M on these considerations is difficult to quantify. The studies to date have not been conclusive. They have centered on the way I/M affects short- and long-run vehicle deterioration curves. The short-run deterioration curve reflects the rate at which a vehicle deteriorates after it has been tuned (Figure 2-3), while the long-run curve reflects the overall degradation in vehicle performance that occurs as it ages (Figure 2-4). Both curves, especially the short-run deterioration curve, influence vehicle performance while the slope of the long-run curve is more likely to be the primary determinant of vehicle longevity. To the extent that I/M influences the short-run curve, it should have a positive impact on vehicle performance. If an engine remains within the manufacturer's specification, it should perform at a higher level due to I/M.

The influence on performance and longevity resulting from I/M's impact on the long-run deterioration curve is unknown. It seems reasonable that a properly maintained vehicle will experience less wear than if it is not maintained to manufacturer's specifications. Assuming this relationship is true, I/M should have a positive effect on vehicle life. The repair of a vehicle

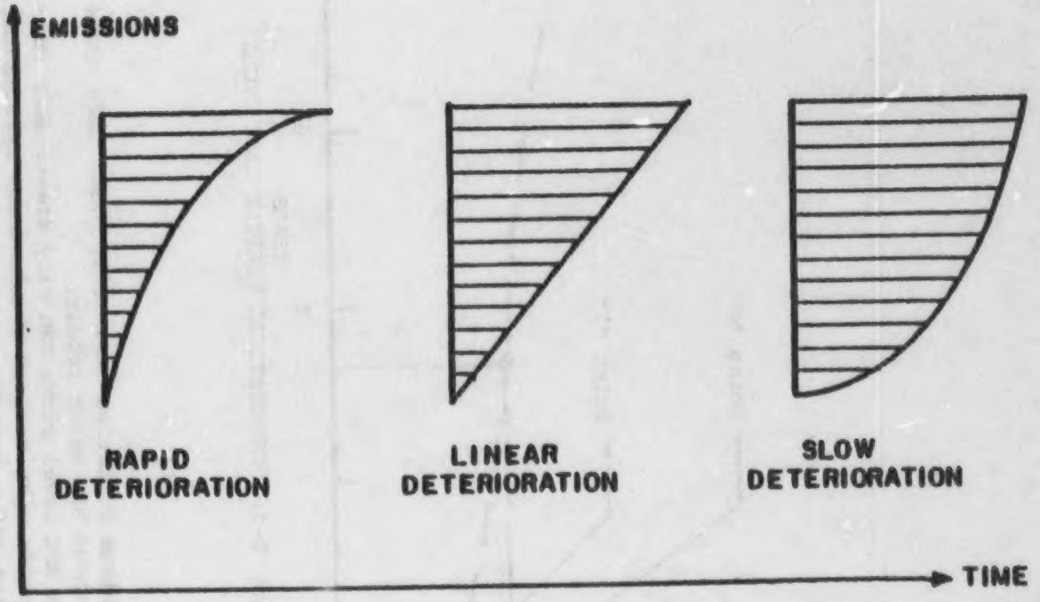


Figure 2-3. POSSIBLE POST MAINTENANCE DETERIORATION FUNCTIONS SHORT RUN

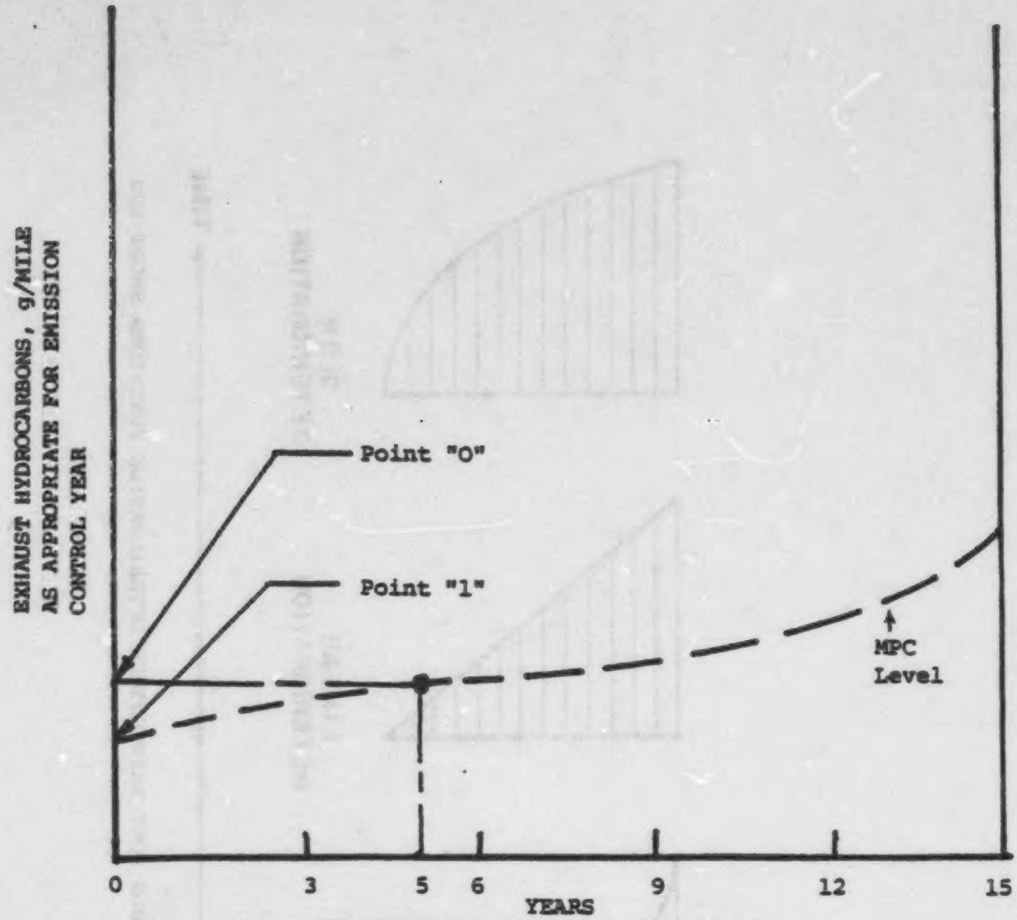


Figure 2-4. HYPOTHETICAL VEHICLE LIFE CYCLE

NOTES:
1. Minimum Pollution Capability (MPC) Life cycle deterioration curve without any major repair.
2. The MPC level curve can vary drastically from vehicle to vehicle. It depends upon vehicle overheating, overloading, etc.
3. Point "O" - Emissions allowable level per Federal Register as required for useful life of 50,000 miles or 5 years
4. Point "1" - Normal vehicle reading of a new vehicle upon certification in order to provide for degradation to the 5-year/50,000 mile warranty.
5. Data developed from Ref. 9. Report to the California Air Resource Board, June 1971, p. 9, Distribution of HC Emissions from the Population of pre-1966 and post-1966 cars on the road.

can reduce emissions to minimum pollution capability (MPC) line after repair to manufacturer's specification level.

Finally, the emission control system performance warranty contained in Section 207 of the Clean Air Act may provide possible benefit to motor vehicle owners under an I/M program. Section 207 of the Clean Air Act mandates a new vehicle and engine emission warranty which includes a general defects warranty in 207(a), a performance warranty in 207(b)*, and an enforcement and recall provision in 207(c). Section 207(a) has generally been interpreted to require manufacturers to warrant vehicles or engines to be free from defects in materials and workmanship that will cause them to violate applicable regulations, including applicable emissions standards.

An applicable list of emissions control items, interpreted as included under this standard and, therefore, makes vehicle manufacturers liable for the failure of these emissions-related parts, is presented in Appendix G. It is assumed that these items could reasonably be expected to degrade the emissions performance of a vehicle. Section 207(b), which specifies a performance warranty generally provided for in 207(a), cannot be implemented at the Federal level until the administrator promulgates a correlatable short test on which the performance warranty can be based. When the EPA determines that a short test is available which is "reasonably capable of being correlated" with the official certification test, then manufacturers will be liable to correct vehicles which fail such a test regardless of whether any specific part defects have been identified.

Manufacturers argue that the Clean Air Act Amendments of 1977 showed that Congress intended to limit the 207(b) performance warranty to "hang-on" components only (e.g.; air pump, catalyst, EGR valve). Congress has diminished the scope of the 207(b) warranty to some extent and its interpretation needs clarification.

It is assumed that the 207(b) warranty presently only applies to "hang-on" components after 24,000 vehicle miles. Before the 24,000 vehicle miles point has been reached, however, 207(b) applies to a broader range of emissions-related components. This range is, as yet, undefined, since the EPA has failed to promulgate a specific list; however, it is clear that Congress intended this list to be broader in application than the "hang-on" component definition.

---

*Performance warranty - means a warranty that a vehicle's emission will not exceed the certification emission standards for its useful life, as evidenced by a correlatable short test.

Congress did not amend the scope of the 207(a) defects warranty; it still applies to a broader range of emissions-related components (as yet undefined on a Federal level) for the full useful life period of 50,000 miles. Warranty, however, has limits with respect to abuse, neglect of improper maintenance. The repair or replacement of any emissions-related part otherwise eligible for warranty coverage shall be excluded from such warranty coverage if the vehicle engine has been abused, neglected, or improperly maintained, and that such abuse, neglect, or improper maintenance was the direct cause of the need for the repair or replacement of the part.

The State of California (Ref. 36) in 1977 completed a surveillance test program on 1975 to 1976 model-year vehicles. These vehicles were tested using:

- CVS-75 test used in new car certification
- Federal Highway Fuel Economy Test (HFET)
- Loaded-mode test
- Acceleration/deceleration driving sequence EPA modal test
- Sealed housing evaporative determination (SHED) test

Only 9 percent of the vehicles failed because of defective components. These defective components may not have been covered by warranty because of:

- Lack of maintenance
- Abuse of vehicle
- Others

It is, therefore, evident that the subject of warranty repair work performed requires further study.

2.5.3.3 Costs of an I/M Program

Costs of an I/M program vary substantially depending on the type of administration, the test mode chosen, the stringency factor, and the local socioeconomic conditions (e.g.; labor rates, land cost, etc.). For convenience, costs of implementing an I/M program are classified into two major categories: capital costs and operating costs. To the consumer, there are two types of costs, namely inspection fee and repair costs. This subsection presents information on costs of existing I/M programs.

Capital and Operating Costs - In Table 2-19, costs of existing I/M programs are presented. In New Jersey, which has a state-operated program, the capital cost per inspection lane was $36,800; the average operating cost was $19,600 per lane. The New Jersey program also included safety inspection. The State of Oregon adopted a lower cost approach of implementing I/M; testing facilities were leased. Total capital costs for the testing equipment and mobile vans required $0.38 million. Operating cost was $2.22 million for biennial tests of approximately 0.5 million vehicles.

Consumer Inspection Fee -.To offset costs of an I/M program, most states charge an inspection fee. The fee is used to pay back capital costs, plus annualize interest cost associated with it and operating costs of the program.

In general, the consumer fee on existing I/M programs ranges from $3.50 to $12. In Nevada, the fee varies from $10 to $33. This fee also includes necessary vehicle adjustment. California fees presently on the inspection of vehicles because of the change of ownership, is $12.

Repair Costs - In addition to the fee for emission inspection, the consumer also has to absorb cost of repair if his vehicle fails the emission test. Several studies have dealt with vehicle repair costs that result from failure of an exhaust emission inspection. Maintenance costs depend primarily on the scope of engine adjustments and/or tune-up indicated by test results, and maintenance instructions given to mechanics, as well as the general condition of the vehicle. Detailed maintenance procedures have been prepared that aid

Table 2-19. EXISTING I/M PROGRAM SUMMARY

PROGRAM TYPE	STATE	ADMINISTRATIVE AGENCY	VEHICLE POP ($X10^6$)	STANDARD		STATION STATUS			COST ($X10^6$)		COST TO MOTORIST
				L.D.V.	H.D.V.	#Lanes	#Sta.	Mobile	Capital[a]	Operating[a]	
I. GOVERNMENT											
A. State	New Jersey	DMV - EPA	3.9 LDVs	Idle 23%	NA	68	38	1	$2.50 (1972) + safety facil.	1.33 (1975)	$3.50 including safety
B. Municipal	Ohio, Cincinnati	Cincinnati APCD	.200 LDVs	Idle 30%	NA	4	1	None	$13k & safety facil.	13 for 11 positions	$3.75 including safety
	Oregon[b] Portland	Portland Met. Ser. District	.550 LDVs (biennial)	Idle 40%	NA	14	7	1	$.38 Leased facil. (1975)	$2.22	$5
	Illinois, Chicago	Dept. Env. Control	1.0 LDVs	Idle 30-35%	NA	10	5	6	2.0 (1973)	1.45 (1977)	Free
II. CONTRACTOR	Arizona,[c] Maricopa and Pima counties	Dept. of Health	1.1 cars, trucks, and motorcycles	Idle[d] 30%	EPA City	36	12	1	$10.5	$4.0	$5
III. PRIVATE GARAGE	Nevada	Dept. Motor Vehicles and Dept. Human Resources	.500 LDVs	Idle	NA	218 Licensed Private Stations			0.17 (1974)	$.43 approx. (1974)	$10.00-$33.00 (including adjustments)
	Rhode Island	Dept. of Transportation	.500 LDVs	Idle 30%	NA	923 Private Garages + 1 State-Operated challenge lane			1.00 (1977)	Part of Capital cost 1st year	$4

[a] Cost data defined as year. To upgrade costs to present year multiply by appropriate inflation factor.

[b] State of Oregon, Oregon Environmental Quality Commission "Report to the Oregon Legislature on the Motor Vehicle Emission Testing Program," January 14, 1977.

[c] State of Arizona, Bureau of Vehicular Emissions Inspections "Tune-up for Less Emission,- It's Working, Arizona Vehicular Emissions Inspection Program Operations, 1977."

[d] Also test with loaded regimes.

Definitions:
DMV - Department of Motor Vehicles.
LDV - Light-Duty Vehicle (GVW <8501 lb.).
HDV - Heavy-Duty Vehicle (GVW >8502 lb.).

mechanics to correctly diagnose engine items that require prescribed adjustment and repair. Unnecessary repairs can be drastically reduced when mechanics are instructed in proper engine diagnostics.

Summarized below are the major report conclusions relating to repair costs for vehicles failing emission inspection criteria.

1. Olson Laboratories, The Short-Cycle Project: Effectiveness of Short Emission Inspection Tests in Reducing Emissions Through Maintenance (1973) (Ref. 23)

   Average repair cost for servicing failed idle vehicles was $29.13 with diagnostic routine. In contrast, average repair cost for servicing failed loaded-mode vehicles with diagnostic routine was $35.20.

   An approximate average of $10 excessive cost was incurred in repairing failed vehicles based upon a review of actual repairs versus diagnostic-noted repair requirements.

   An approximate average of $4 excessive cost was incurred in repairing failed vehicles after a more thorough training of repair shop mechanics was completed.

2. Elston and Cooperthwait, New Jersey's Auto Emission Inspection Program: An Assessment of One Year's Mandatory Operation (June 1975) (Ref. 9)

   During the first year of mandatory I/M, 80 percent of all failed vehicles in New Jersey required only idle adjustments or minor tune-ups. Average repair cost was less than $40.

3. Scott Research Laboratories, Inc. Exhaust Emission and Test Evaluation of the State of California Roadside Idle Emission Inspection Program and State of California Evaluation of Mandatory Vehicle Inspection and Maintenance Programs (Ref. 32)

In this study, approximately 100 vehicles failed to pass inspection requirements; subsequently, they were directed to 34 different Class A repair stations located in the San Bernardino and Riverside areas of California. There was an observed $10 difference in repair costs between San Bernardino ($36.06) and Riverside ($26.10).

Supplemental data provides average repair cost information broken down by vehicle model-year and service industry (Tables 2-20 and 2-21).

Table 2-20. AVERAGE REPAIR COST BY VEHICLE MODEL-YEAR

Model-Year	Number Vehicles Repaired	Average Repair Cost
1966	10	$29.39
1967	13	37.89
1968	13	42.10
1969	14	37.72
1970	24	21.23
1971	16	32.49
1972	8	33.47
1973	2	26.10
1975[a]	33	53.00

[a] Riverside data - range $8 to $175 (Ref. 32).

Vehicles manufactured in 1967 through 1969 had comparatively high average repair bills. In contrast, late-model vehicles (1970 to 1973) were slightly lower.

Table 2-21. SERVICE INDUSTRY REPAIR COSTS
A. RIVERSIDE STUDY REPORT - 1975

Service Industry	Number Sampled	Average Cost Repair
Dealership	27	$45.86
Independent garage	28	28.59
Service	45	26.05

B. ARIZONA - DECEMBER 1977 REPORT (REF. 1)

TYPE FACILITY	1964-1967	1968-1977	1964-1977
Franchised dealers	$41.25	$26.82	$27.97
Service stations	23.06	19.81	21.14
Merchandisers	15.53	20.29	19.43
Tune-up specialists	36.19	22.86	24.72
Independent garages	21.33	27.46	26.79
"Do-It-Yourselfers"	14.27	20.61	19.08

Dealerships, as indicated in this survey have the highest average repair costs. Repair costs from independent garages and service stations are similar, but significantly lower than dealerships.

4. Clean Air Research Company, An Evaluation of the Effectiveness of Automobile Engine Adjustments to Reduce Exhaust Emissions (Ref. 5)

The average cost to repair 300 vehicles was $27.47 per vehicle for both controlled and uncontrolled vehicles representing the 1957 to 1970 California vehicle population.

5. Additional Repair Cost Studies - Additional repair cost studies are presented in Table 2-22. Repair costs for idle- and loadedmode testing are similar.

Table 2-22. AVERAGE REPAIR COSTS FOR FAILED VEHICLES

	Idle	Idle Overcharge	Loaded	Loaded Overcharge	Stringency Factor
California Study (Ref. 3)	$21	$2	$23	$5	35%
Northrop (Ref. 19)	34	-	30	-	50
EPA (Ref. 41)	26	8	28	7	50
Olson (Ref. 21)	26	-	-	-	50

Both the idle and loaded emission inspection programs can be performed on a benefit/cost basis if the cost of I/M is measured against the amount of emission reduction and fuel savings achieved. For most owners of rejected vehicles, the cost of maintenance is well within tolerable limits. For the very small percentage of vehicles that would require a major tune-up to meet established emission criteria, states could set a ceiling on the maximum dollar amount that would be required to be expended for emissions-related adjustments.

Repair Cost Ceilings - It may be desirable for the State to regulate emission repair costs. This would be accomplished by fixing maximum price ceilings on all emission repair work. Table 2-23 examines the effect of reducing the maximum repair cost ceiling on percentage of failures repaired,

Table 2-23

EFFECT OF REDUCING THE MAXIMUM REPAIR COST (IN 1976 DOLLARS)

MAXIMUM REPAIR COST	PERCENT OF FAILED REPAIRED		AVERAGE[a] REPAIR COST		AVERAGE[b] FUEL ECONOMY IMPROVEMENT		TOTAL EMISSION REDUCTION			
							HC		CO	
	Idle	Loaded	Idle	Loaded	Idle	Loaded	Idle	Loaded	Idle	Loaded
$150	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
$140	100	100	100	100	100	100	100	100	100	100
$130	100	100	100	100	100	100	100	100	100	100
$120	100	100	100	99	100	100	100	100	100	100
$110	100	99	100	94	100	100	100	99	100	99
$100	100	98	100	92	100	100	100	98	100	98
$90	99	97	97	90	99	100	99	97	100	98
$80	97	96	91	87	96	92	96	93	97	95
$70	97	94	91	82	96	83	96	90	97	87
$60	96	92	88	76	93	76	94	87	95	81
$50	94	88	85	60	91	77	93	83	92	76
$40	88	84	75	64	85	63	90	78	85	68
$30	86	77	72	56	85	70	81	65	82	63
$20	67	69	60	50	51	67	53	49	69	57

[a] At 100 percent all repair costs were included in establishing the average repair cost. Below 100 percent the maximum repair included only the noted percentage of repairs.

[b] At the stated maximum repair cost, the noted percentage of fuel savings was included in the average calculations. The possibility of further improvement in fuel economy is the difference between 100 percent and the noted percentage.

average repair cost, average fuel economy, and total emission reduction. For example, as the maximum repair cost is reduced from $150 to $100 ($10 increments), there are no observed reductions. However, if the maximum repair cost is lowered below $100 (baseline), there are 2 percent to 4 percent reductions in every category. This seems to indicate that there is a compromise point between what the public is willing to pay (repair cost ceiling) and the desired level of emission reduction, fuel economy, and average repair cost.

Once the maximum repair cost ceiling is established, vehicles with consumer repair work exceeding the cost ceiling would be exempt. This avoids placing undue economic hardships on owners. The cost of exempting certain vehicles from having emissions-related repair work performed, is the reduction in the overall effectiveness of the program. Given the relatively small percentage of major emissions-related repair work, however, it would appear that little decrease in overall emissions reduction would result from the exemption of some vehicles. This is based upon the fact that in Oregon and Arizona only 2 percent of the tested vehicles cost more than $100 to repair. In New Jersey, the figure was 5.6 percent. It would appear, therefore, that the gains in terms of public acceptance would tend to outweigh any decrease in emission reduction resulting from the waiving of repair requirements for certain vehicles.

2.5.4 Comparison of Benefits and Costs Between Idle-Mode and Loaded-Mode

Studies of emission and fuel reductions for idle- and loaded-mode testing have been summarized in Table 2-24. A study by the California ARB indicated that there was no statistically significant difference between the effects of the two test modes on emissions, fuel economy, or average repair cost (Ref. 35). A similar study by the Northrop Corporation showed emissions reductions comparable to those in the California study while using a 50 percent failure rate (Ref. 19). It also indicated no significant difference in HC reductions between the loaded and idle test modes, while the loaded test resulted in a greater CO reduction and a significant increase in NO_x. An EPA report indicated that the loaded test resulted in larger HC and CO reductions than the idle test when both test modes were evaluated at a 50 percent failure rate (Ref. 41).

Table 2-24. COMPARISON OF EMISSIONS AND FUEL CONSUMPTION REDUCTIONS AND REPAIR COSTS FROM OTHER STUDIES

	IMMEDIATE REDUCTIONS - FAILED VEHICLES				ASSUMED
	HC	CO	NO_x	Fuel Consumption	FAILURE RATE
Idle Regime					
California Study	38%	33%	4.2%	3.8%	35%
Northrop	40%	37%	-13%	-	50%
EPA	42%	34%	5.0%	-	50%
Olson	38%	29%	-7.3%	3.0%	50%
Loaded Mode Regime					
California Study	36%	34%	-4.3%	1.1%	35%
Northrop	42%	50%	-37%		50%
EPA	56%	42%	-13%		50%

	AVERAGE REPAIR COSTS - FAILED VEHICLES				
	Idle Total	Idle Overcharge	Loaded Mode Total	Loaded Mode Overcharge	
California Study	$21	$2	$23	$5	35%
Northrop	$34	-	$30	-	50%
EPA	$26	$8	$28	$7	50%
Olson	$26	-	-	-	50%

It is important to point out that the idle test has no ability to detect malfunctions of NO_x control systems. This is because most NO_x control systems are not designed to operate at idle conditions, and NO_x emissions at idle are negligible. Although the studies in Table 2-24 produced negative NO_x reduction benefits with loaded-mode testing, they do not imply that the loaded test does not have the capability of reducing NO_x emissions. In fact, a special test performed during the California study revealed that a loaded-mode NO_x inspection standard resulted in the failure of 45 percent of the cars which had malfunctioning NO_x controls. Inclusion of the NO_x inspection standard resulted in an immediate 24 percent reduction in NO_x emissions from failing vehicles. The results indicate that a NO_x inspection standard used in a loaded-mode test regime can have a great potential for detecting and pinpointing malfunctioning NO_x controls. This potential is not available with idle-mode testing.

The loaded-mode test usually provides more specific diagnostic information than the idle test mode does. Ideally, the diagnostic information should assist mechanics in repairing the automobile. However, this benefit cannot be fully realized without enhanced mechanic training programs. Table 2-25 summarizes benefits comparisons.

Table 2-25. GENERAL BENEFITS COMPARISON OF TEST MODES

Benefit Items	Idle Test	Loaded Test
1. Emissions Reductions	HC, CO reductions as effective as loaded test No NO_x reduction potential	HC, CO reductions same as idle NO_x reduction potential
2. Fuel Savings		Same as idle
3. Diagnostic Information	Minimum	Provides more specific information for repairing

Costs comparisons of these two test modes are described in Table 2-26. The cost-scale factor is defined as the cost ratio of loaded testing to idle testing. Generally speaking, loaded testing requires more investment costs for the facility in terms of test equipment, as well as higher operating costs for personnel, quality control, and maintenance. Administrative-related costs

Table 2-26. GENERAL COST COMPARISON OF TEST MODES

COST ITEMS	IDLE TEST	LOADED TEST	COST SCALE FACTOR
Investment Costs			
1. Area required	Minimum space requirement	Require larger space to accommodate dynamometer	1.44
2. Facility required	Minimum number	More facilities because of slower throughput rate	1.28
3. Test equipment	NDIR, HC/CO analyzer, manual data processing system	NDIR, HC/CO analyzer, chassis dynamometer, manual data processing system	6.77*
4. Administrative related		Same as idle test	1.00
Operating Costs			
5. Personnel	Minimum	Same as idle test but with higher level skill	1.17
6. Quality control (QC)	Minimum	Need frequent monitoring and calibration	1.00
7. Training	Minimum time and frequency	More training time and frequency	2.00
8. Maintenance	Minimum	Higher cost	2.02
9. Administrative related		Same as idle test	1.00

*If semi-automated data processing equipment costs are added to each mode, the cost scale factor is lowered to 2.40.

for public relations, program administration, etc., are approximately the same for both test modes.

2.5.4.1 The California ARB Study

In 1976 the ARB of the State of California completed a study to evaluate alternative mandatory vehicle inspection and maintenance programs. The study compared the effects of an idle test mode program and a loaded test mode program. Conclusions of the study were:

- Either an idle- or a loaded-mode I/M regime has the potential to provide significant and cost-effective reductions in HC and CO, with a slight improvement in fuel economy.
- Given the current abilities of the service industry in California, there is little justification for the extra cost of a loaded-mode inspection program.

In Table 2-27 program costs of different alternatives are compared. All costs are expressed in 1976 dollars. The table was established within the following constraints:

- All cars in the South Coast Air Basin (vehicle population of 7 million vehicles) are tested
- All costs are amortized over 3 years
- A reinspection for failed vehicles is included
- 272 lanes/78 inspection stations are built
- Inspection costs are $5.00 to $5.10 for the first 3 years and about $3.95 to $4.50 per vehicle thereafter.

The costs are influenced by the emissions standards that are established. The California emissions standards are set forth in Table 2-28.

Table 2-27. MVI PROGRAM COSTS - SOUTHERN CALIFORNIA

Item	Loaded-Mode with Engine Analyzers (Potential for Safety) (a)	Loaded-Mode (b)	Idle (Potential for Loaded-Mode, Engine Analyzers, and Safety) (c)	Idle (d)
I. Capital Investments				
1. Site and Building Acquisition (e)	$814,000	$814,000	$679,000	$679,000
2. System Hardware and Installation (f)	15,069,000	14,307,000	8,676,000	8,127,000
3. Other Equipment and Start-Up Costs (g)	1,696,000	1,696,000	987,000	987,000
4. Program Design (h)	500,000	500,000	500,000	500,000
5. Program Evaluation (i)	1,000,000	1,000,000	1,000,000	1,000,000
6. Public Information (j)	400,000	400,000	400,000	400,000
7. Training & Enforcement (k)	150,000	150,000	150,000	150,000
Total Capital Investments (l)	$19,629,000	$18,867,000	$12,392,000	$11,843,000
II. Annual Operating Costs				
1. Building Lease (m)	$4,740,000	$4,414,000	$3,943,000	$3,343,000
2. Salaries (n)	17,666,000	17,666,000	14,902,000	14,902,000
3. Operating Expenses and Equipment (o)	1,618,000	1,618,000	1,566,000	1,566,000

Table 2-27. MVI PROGRAM COSTS - SOUTHERN CALIFORNIA (Continued)

4.	Equipment Amortization and Replacement (p)	4,130,000	3,921,000	2,378,000	2,227,000
5.	On-going Program Evaluation (q)	50,000	50,000	50,000	50,000
6.	Public Information	20,000	20,000	20,000	20,000
7.	Training and Enforcement	50,000	50,000	50,000	50,000
	Total Annual Operation Costs	$28,274,000	$27,739,000	$22,909,000	$22,158,000
III.	Inspection Costs per Vehicle				
1.	Capital Investments (first 3 years only)	$1.08	$1.03	$ .68	$.65
2.	Operating Costs	$4.04	$3.96	$3.27	$3.17
	Total	$5.12	$4.99	$3.95	$3.82

Notes

A) Implementation of a loaded-mode MVIP, including the use of engine analyzers and with room to add a safety inspection at a later date.

B) Implementation of a loaded-mode MVIP, with no engine analyzers and with no room for expansion to include safety.

C) Implementation of an idle MVIP, but with the capability to expand to a loaded-mode emissions and safety inspection, including the use of engine analyzers, at a later date.

Table 2-27. MVI PROGRAM COSTS - SOUTHERN CALIFORNIA (Continued)

D) Implementation of an idle MVIP, but with no capabilities for expansion to loaded-mode or safety inspections.

E) Costs incurred by General Services to locate and procure sites for inspection stations. Based on costs for the Riverside pilot program, confirmed by General Services as typical. Source: ARB Contract 4-855.

F) Includes all major hardware costs, based on actual expenses for the Riverside pilot program but reduced by 10% to account for volume purchases. Hardware related only to loaded-mode deleted in scenarios (c) and (d). Installation costs are 35% of hardware costs, based on the Riverside pilot program.

G) Office furniture, administrative supplies, and miscellaneous one-time start-up costs. Source: ARB estimate, conversations with BAR.

H) Costs of designing and optimizing the stations based on the experience gained in the pilot phase. Source: ARB estimate.

I) Cost of conducting a surveillance and evaluation program, as discussed in the recommendations. Source: ARB estimate.

J) Costs of preparing and publishing information pamphlets and of preparing public service television and radio spots to inform the public about the program. Source: ARB estimate.

K) Costs of procuring automobiles and training and inspection equipment for twenty-five new training and enforcement personnel. Source: ARB estimate.

L) These costs are funded by a loan from the State Transportation Fund, which must be repaid at 9% interest within 3 years with payments due quarterly. Source: Department of Finance.

Table 2-27. MVI PROGRAM COSTS - SOUTHERN CALIFORNIA (Continued)

M) Based on discussions with General Services personnel involved in site selection and procurement for the change of ownership phase. These leases assume that the State signs a 10-year firm, 15-year lease for all stations. Source: General Services.

N) Includes personnel for administration, operations, support, public information, data analysis, program evaluation, training, and enforcement. Source: ARB and BAR estimates, based on Olson design study and pilot Riverside program.

O) General administrative and support operating expenses, including those for inspection facilities. Source: ARB and BAR estimates based on Olson design study and pilot Riverside program.

P) 37% of system hardware costs. Source: Olson design study.

Q) Costs of routine data analysis and studies for the refinement of inspection standards and procedures. Source: ARB estimate.

Other Assumptions

The number and type of facilities is based on output rates which were empirically determined at the Riverside MVIP station, and on an estimated 7 million feepaying vehicles per year with one reinspection required for the 35% failing vehicles.

	2-lane Stations	4-lane Stations	Total Stations	Total Lanes
Loaded-mode	20	58	78	272
Idle	17	48	65	226

Table 2-28. IDLE REGIME STANDARDS MVIP SURVEILLANCE STUDY
STATE OF CALIFORNIA

Model Year	Type Control	More Than Four Cylinders		Four Cylinders or Less	
		HC	CO	HC	CO
1955-1965 (Domestic) 1955-1967 (Import)	None	1200	8.0	1800	8.0
1966-1970 (Domestic) 1968-1970 (Import)	AI	350	4.5	350	3.0
1966-1970 (Domestic) 1968-1970 (Import)	Other	500	6.0	600	6.0
1971 and later	AI	200	3.0	275	3.0
1971 and later	Other	350	4.5	400	5.0

Section 3

GENERAL DEFINITIONS

These definitions and abbreviations are used in inspection and emissions testing procedures.

accuracy: The degree by which an instrument is able to determine the true concentration of a pollutant in the exhaust gas sampled.

air contaminants: Any fumes, smoke, particulate matter, vapor gas, or any combination, excluding water vapor or stream condensate.

air-fuel ratio: The expression of the proportionate mixture of air to gasoline accomplished by the carburetor. Usually expressed as a numerical relationship such as 14:1, 13:1, etc.

ambient air: The surrounding environmental air.

calibration gases: A blend of HC and CO gases using nitrogen as the inert carrier gas.

carbon monoxide: A nonirritating, colorless, odorless gas which has the molecular form of CO.

catalytic converter: Device to reduce automobile emissions by converting CO and HC emissions to harmless carbon dioxide and water.

Certificate of Compliance: A document that is issued upon completion of inspection which records the results and serves as proof of inspection for vehicle owner.

certified mechanic: An individual certified by the state or I/M program office, to install, repair or adjust motor vehicle engine emissions-related components and pollution control devices so that the vehicle will meet emissions standards.

certified station: A private facility certified by the state or I/M program office, to install, repair or adjust motor vehicle engine emissions-related components and pollution control devices so that the vehicle will meet applicable emissions standards.

chassis dynamometer: A test instrument equipped with two parallel rollers that support the rear wheels of a motor vehicle. When positioned on the dynamometer the vehicle may be "driven" to simulate the road operation. A power absorption unit is connected to the rollers to simulate the loading from the various sources of fluid and mechanical friction present during road operation. Weights can also be coupled to the rollers to simulate the inertial effects of vehicle mass during acceleration and deceleration.

crankcase emissions: The products of combustion emitted into the ambient air from the engine crankcase ventilation system.

degradation: The decreased effect of I/M on emission reduction due to normal wear of engine.

deterioration: A synonym for degradation indicating an increase in emission levels due to wear.

drift: The amount of meter reading change over a period of time. Zero drift refers to change of zero reading when off. Span drift refers to a change in reading of a calibration point on the upper half of the scale. The calibration point is established by reading a certified calibration gas of known concentration.

emission inspection program: An inspection and maintenance program in which each vehicle is subjected to a test of its emissions under specified conditions. The emission levels are compared with a standard established for the vehicle class. If the emissions are higher than the standard, the vehicle fails and must be adjusted or repaired to bring its emissions to within the standards.

engine family: The basic classification unit of a manufacturer's product line used for the purpose of test-fleet selection.

engine-system combination: An engine family-exhaust emission control system-fuel evaporative emission control system combination.

exhaust gas analyzers: Instruments which can determine the amounts of one or more gas(es) in the exhaust of a motor vehicle.

exhaust emissions: The gases emitted into the ambient air from any opening downstream of the exhaust ports of an internal combustion engine.

failure rate: The percentage of total vehicles tested in an inspectional program that fail inspection and repair.

fleet-owner authorized stations: A permit issued to a qualified fleet owner to perform vehicle emissions inspection limited to his fleet only.

fleet operator: The owner of a fleet of 10 or more vehicles.

fuel system: Combination of fuel tank, feeder lines, fuel pump, and evaporative emissions control system.

gross vehicle weight: The manufacturer's gross weight rating for the individual vehicle.

HC hang-up: HC that clings to the surface of the sampling and analyzer system in contact with the gas sample stream and causes an erroneous indication of HC in the measured value.

heavy-duty vehicle: Any motor vehicle designed for highway use having a gross vehicle weight of more than 8,500 pounds.

hydrocarbons: A compound whose molecular composition consists of atoms of hydrogen and carbon only.

idle test: An emission inspection program that measures the exhaust emission from a motor vehicle operating at idle. (No motion of the rear wheels.) A vehicle with an automatic transmission may be in "drive" with brakes applied, or in neutral.

independent contractor: Any person, business firm, partnership or corporation with whom the state may enter into an agreement providing for the construction, equipment, maintenance, personnel, management and/or operation of official inspection stations.

inspection and maintenance program: A program to reduce emissions from in-use vehicles by identifying vehicles that need emissions control-related maintenance and requiring maintenance to be performed.

inspection station: A facility for inspecting motor vehicles and pollution control devices for compliance with applicable regulations.

inspector: An individual who inspects motor vehicles and pollution control devices for compliance with applicable regulations.

instrument: The system which samples and determines the concentration of a particular gas of interest.

light-duty vehicle: A motor vehicle designed for highway use, and less than 8,500 pounds gross vehicle weight. Further distinctions are sometimes made between light-duty automobiles and light-duty trucks, such as pickup trucks.

loaded test: An emission inspection program that measures the exhaust emissions from a motor vehicle operating under simulated road load on a chassis dynamometer.

model year of vehicle: The production period of vehicles designated by the calendar year in which such period ends.

motorcycle: A motor vehicle having a seat or saddle for the rider, and designed to travel with not more than three wheels in contact with the ground, but excluding a farm tractor.

motor vehicle: Any self-propelled vehicle which is designed primarily for travel on public rights-of-way and is used to transport persons and/or property.

oxides of nitrogen: Any molecule containing nitrogen and oxygen only.

positive crankcase ventilation: A system that returns blowby gases from the crankcase of the engine to the intake manifold, to burn them in the engine. Blowby gas is unburned fuel/air mixture that leaks past the piston rings into the crankcase during the compression and ignition cycles of the engine. Without positive crankcase ventilation, these gases which are rich in hydrocarbons, escape to the atmosphere.

prescribed inspection procedure: Approved procedure for identifying vehicles that need emissions control-related maintenance.

quality: The results of engineering and manufacturing that determine the degree to which the product meets design specifications.

quality assurance: Validation procedure to insure that the product meets the design specifications.

registered owner: An individual, firm, corporation or association whose name appears in the files of the motor vehicle registration division of the Department of Motor Vehicles as the owner of the vehicle.

reliability: An instrument's capability to provide the same value for successive measures of the same sample.

response time: The period of time required for an instrument to provide a read-out after a step-change in gas concentration level initiated at the tail pipe sample probe.

smoke: Small gasborne particles, exclusive of water vapor, resulting from combustion in sufficient number to be visible.

pollution control device: Equipment designed for installation on a motor vehicle reduce pollutants emitted from the vehicle, or an engine modification resulting in pollutant reduction.

tampering: The alteration, modification, or disconnection of emission control devices.

vehicle dealer: An individual, firm, corporation or association who is licensed to buy, sell or trade motor vehicles.

vehicle emissions standard: A specific emission limit allowed for a class of vehicles. The standard is normally expressed in terms of maximum allowable concentrations of pollutants (e.g., parts per million). However, a standard could also be expressed in terms of mass emissions per unit of time or distance traveled (e.g., grams per mile).

Part III

TECHNICAL AND ECONOMIC ANALYSES

Section 1

INTRODUCTION

Part III of the Motor Vehicle Inspection and Maintenance for the State of Tennessee Final Report presents base data and methodology of the study, and provides the findings and results of the analyses. This information is presented in nine sections, Section 1 describes the program under study, summarizes the cost methodology, and presents general assumptions for the anlyses.

Section 2, Data Base and Methodologies present cost, benefit, and vehicle projection data for the costs analyses, identifies personnel requirements, and discusses fuel saving methodology.

Sections 3 to 6 provide detailed cost analyses of the four options designated by the State of Tennessee. Consumer fees to cover program costs of the various option are also presented.

Section 7 presents benefit analyses. This includes emission reductions, fuel savings, failure rate and estimated repair costs, and value of warranty repair.

Section 8 presents discussion and analyses of independent program variables. Topic covered are enforcement, consumer protection, quality assurance, data management system design, legislative considerations, mechanic training, inspection station facilities, program finding, and inspection frequency.

Section 9 presents the I/M program implementation schedule.

Preceding page blank

1.1 PROGRAM DESCRIPTION

A motor vehicle inspection/maintenance (I/M) program scenario for the State of Tennessee is as follows:

- Idle mode-testing
- Testing of all gasoline-powered, light-duty autos and trucks (less than 6,000 pounds GVW)
- Testing of the above described vehicles registered in the counties of Davidson, Hamilton, Knox, and Shelby
- Annual testing and maintenance for all vehicles
- Setting of failure standards so as to produce a 30 percent failure rate

The ownership and operation of the testing facilities is treated as a variable in this study and could be accomplished by any one of the following options:

- State operation - Option 1
- Franchised contractor operation - Option 2
- Private garage-operation - Option 3
- State administration and local county operation - Option 4

The criteria by which these alternatives will be evaluated are the benefits which are produced and the costs which are required.

1.2 COST METHODOLOGY

I/M program costs were grouped into the following five categories:

- Construction costs
- Other capital costs

- Initial implementation costs
- Annual operating costs
- Consumer protection costs

First three cost categories included those resources and functional costs that were related to initial investment, capacity expansion and implementation. Operating costs covered the annually required costs that are necessary to operate the I/M program. Consumer protection costs covered costs of mechanic training program, public information program and enforcement.

General descriptions of each cost category are presented in the following paragraphs.

1.2.1 Construction Costs

Based on the physical locations selected for the inspection facilities, the land area required for facility placement must be acquired, either purchased or leased, if not already owned.

New facilities must be, then, constructed to comply with the facility plans and drawings. Completed facilities should be inspected and certified for acceptance.

1.2.2 Other Capital Costs

This category covers initial capital costs which in general are not included in other categories. Cost items are administrative office equipment, quality control equipment, and enforcement.

1.2.3 Initial Implementation Costs

Implementation of an I/M program will require the expenditure of monies for noncapital items and services on a one-time basis prior to the actual start-up. Costs of this nature are difficult to define. They generally include initial administrative effort, development of standards and specifications, system checkout, and personnel training.

1.2.4 Annual Operating Costs

Annual operating costs include all costs associated with the actual operation of the I/M program. For the purpose of analyses, consumer protection costs are not included; rather they are identified as a separate cost category.

1.2.4.1 Facility Operation

For a private garage-operated facility, the operation cost include wages and overhead. Wages are compensation for personnel who inspect and test vehicles. The overhead need to cover equipment, facility maintenance, utilities, supplies, and taxes.

1.2.4.2 Support Costs

The costs include in this group reflect the overall program administration effort. Specifically, salaries of administrative personnel, office supplies, office rental, and data analysis cost are included.

1.2.4.3 Quality Control Costs

Quality control costs consist of certification and recertification of test stations, mobile unit operation, instrument maintenance, personnel costs, supplies, data analysis, and administraive cost pertinent to quality control operation.

Prior to receiving the first inspection vehicle, the total facility must be qualified and certified. It was previously stated that the approved equipment is certified after installation. Additional tests would be conducted on the total system of equipment, personnel, procedures, and documentation to assure uniformity on a statewide basis.

The quality control program requires mobile vans to calibrate all test equipment in each facility.

1.2.5 Consumer Protection Costs

This cost category include operating expenditures for mechanic training, public information and enforcement programs.

1.2.5.1 Mechanic Training

The air quality benefit for an I/M program is dependent, in part, on the ability of the service industry to properly perform the repair work necessary to lower emission. Thus, a proper training program would enhance benefits of emission reductions.

The cost of mechanic training can be defrayed through a charge for the training course. In the cost analysis, it is not included in the program cost.

1.2.5.2 Public Information

The experience with I/M program operation shows that there is a definite requirement for a virogous public information effort. Cost of public information covers newspaper, television, and radio advertisements, pamphlet distribution, and public speech, etc.

1.2.5.3 Enforcement

Costs of enforcement include spot checks in in-use vehicles, salaries of enforcement officers, operation cost of enforcement vehicles.

This cost analysis will include estimation of costs in each category. In order to calculate consumer fee charge, program cost that comprise these costs categories will be converted into uniform annualized cost. The fee is then calculated by dividing the total annualized costs by the average of vehicle population over program operation period. The fee assumes a free reinspection for each of the failed vehicles. The fee along with all other costs is expressed in 1978 dollars. To get fee in actual dollars, one must adjust for inflation. Detailed discussion is presented in Appendix I.

1.3 ASSUMPTIONS

The anayses in this study were based upon the following assumptions:

- The program operation is over a period of 6 years starting in 1982

- Double-lane facilities will be built

- The private garages in Option 4 of Table 4 would assume the cost of purchasing test equipments

- Contractor costs to cover general administration (G/A) and certain overhead costs, not identified in the cost categories are as follows:
  - G/A is 15 percent
  - Undefined overhead such as certain indirect costs related to supplementary personnel, administrative, accounting, purchasing, financial, etc., activities is assumed to be 50 percent
  - Contractor's profit is 10 percent

- Capital Investment Per Station

  $4,000 - Cost of emission testing and auxilliary equipment

- Operations Throughput Time

  3.75 minutes

- Mechanics Costs (including overhead)

  $18 per hour

- The total number of private garages that would participate in the program was assumed to be 578.

- Predicted emissions data was supplied by the State of Tennessee Department of Transportation.

- Cost of capital is 6 percent for the State.

- The State personnel benefits including sick leave, vacation, retirement, insurance holidays, etc., is 17 percent of base rate.

- Fuel cost is $0.75 per gallon.

- AT an inflation rate of 7 percent, the compound factor for 1982, assuming a 1978 base, is 1.311, and for 1987 it is 1.838.

- Indirect costs reflecting the cost to consumers for waiting time at inspection lanes and cost of transportation to and from the inspection and repair facilities were ignored.

- Average miles traveled per year for LDVs is 11,500 miles per year.

- Failed vehicles consumed 3.8 percent more fuel than the FMVCP certified vehicle on an average.

- Assumed miles-per-gallon fleet average for LDVs is 20 miles-per-gallon (1982), 24 miles-per-gallon for (1987).

- Existing vehicle emission facilities in Hamilton and Shelby counties were not considered in the cost evaluation.

Section 2

DATA BASE AND METHODOLOGIES

2.1 PROGRAM DESCRIPTION

This section is organized to provide detailed background data on program costs, geographical areas, personnel requirements, vehicle categories, test mode, administrative options, enforcement, public relations, and benefits.

2.2 UNIT COST RELATED DATA

The cost functions and their elements are presented in Table 2-1. All costs are based upon 1978 dollars. Where program costs are specified they are stated in constant dollars. They do not reflect an inflation factor.

2.2.1 Construction Costs

Construction costs involve capital outlay required to design a facility, develop a site (land and off-site improvements), construction of facilities, and the procurement of equipment and instrumentation necessary to implement an I/M program. Described below are the major construction cost categories with base cost factors as noted.

2.2.1.1 Land and Off-Site Improvement Costs

Land Cost - Based on the physical locations selected for the inspection facilities, the land area required for station placement must be purchased if not already owned. This cost element requires special consideration, regardless if State- or private contractor-operated.

Preceding page blank

TABLE 2-1. OUTLINE OF PROGRAM COST CATEGORY/ELEMENTS

Item	Activity
I.	CONSTRUCTION COSTS (CAPITAL INVESTMENT)
1.	Land and Off Site Improvement Cost
	a. Land Cost
	b. Off Site Improvement Costs
2.	Facility Cost
	a. Construction Cost
3.	Instrumentation Cost
	a. Primary Test Equipment
	b. Ancillary/Maintenance Equipment
4.	Office Equipment
5.	Computer Costs
	a. Hardware
	b. Software
II.	OTHER CAPITAL COSTS
1.	Administrative Office Equipment
2.	Quality Control Equipment
	a. Mobil Unit
	b. Referee Station
	c. Correlation Car
3.	Consumer Complaint
4.	Vehicle Test Scheduling
III.	INITIAL IMPLEMENTATION
1.	Site Selection
2.	Bids Preparation and Evaluation
3.	Design of Facility
4.	Training Plan Development
5.	Personnel Selection
6.	Document Preparation
7.	Administrative Support
8.	Initial System Certification
9.	System Integration and Checkout
IV.	ANNUAL OPERATING COSTS
1.	Facility Operating Costs
	a. Personnel Costs
	b. Maintenance and Miscellaneous Item Costs
	1. Facility
	2. Equipment
2.	Quality Control Operating Costs
	a. Administrative Supply Costs
	b. Mobil Unit and Referee Lane Maintenance Operation Costs
	c. Correlation Vehicle Operation Costs
3.	Support Costs
	a. Administrative
	b. Data Analysis
	c. Fee Collection and Vehicle Registration
	d. Training
V.	CONSUMER PROTECTION COSTS
1.	Mechanic Training
2.	Public Information Program
3.	Complaint Follow-Up
	a. Consumer Affairs
4.	Vehicle Test Scheduling Costs

A number of issues, beyond the obvious one of land area, are extremely crucial in estimating land costs. The basic unit cost as established from real estate contacts is, for example, lot-specific to the extent that the cost per square foot within any mile-square may vary by a factor of 3; within any city or town, the cost may vary by a factor of 10 or more.

Land cost estimates were developed from information supplied by the State of Tennessee, and past design data on the general requirements for a minimum size one position 2-lane idle-mode test facility. These data can be factored up to meet the physical requirements of larger units or a loaded-mode facility.

The site plan for a typical one position 2-lane idle-mode test facility is presented in Figure 2-1.

2.2.1.2 Test Facility Cost

Construction Cost

Test facility costs may vary in accordance with specific design features. The layout presented in Figure 2-1 was considered the minimal facility size for a two-lane system. State of Tennessee and Dodge Manual data (Ref. 52, 57) presented in Table 2-4, indicates standard construction costs for a concrete structure at $16 per square foot. A pre-fabricated unit can be purchased for $3 to $5 a square foot. Additional construction improvements would cost another $4 to $5. Total construction costs are estimated at $7 to $10 per square foot for a prefabricated unit. Improvements to the building site including pavement and landscaping would cost an additional $1.20 per square foot. The construction costs for this study are computed for the concrete structure option.

2.2.1.3 Instrumentation Cost

Primary Test Equipment Costs

Equipment recommended for a particular test methodology must be purchased and installed. The equipment and support instrumentation is interdependent

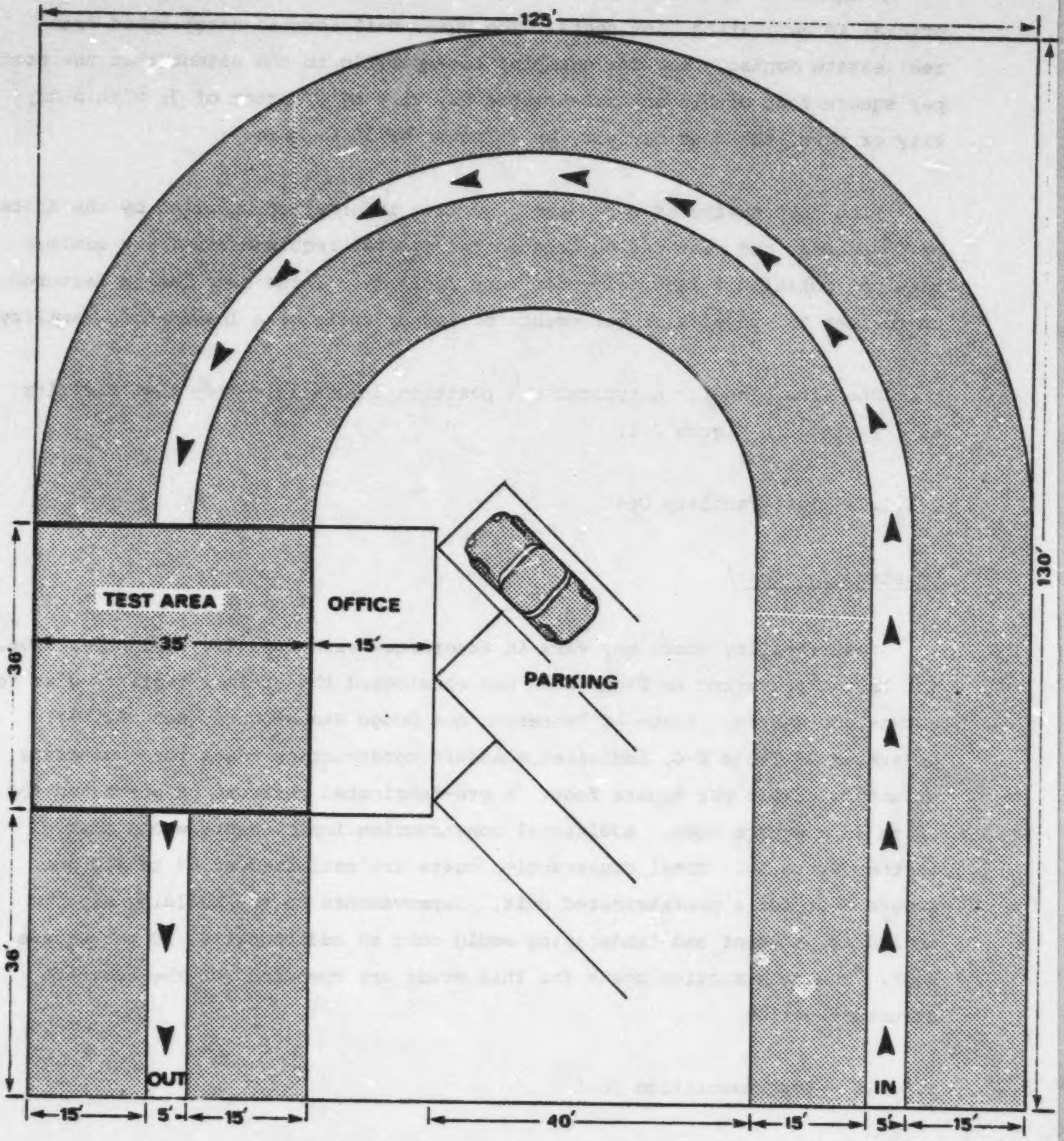

125′
130′
TEST AREA
OFFICE
35′
15′
PARKING
36′
36′
OUT
IN
15′
5′
15′
40′
15′
5′
15′

Figure 2-1. ONE POSITION TWO-LANE IDLE-MODE TEST FACILITY

with, and must be defined in terms of, the test regime and applicable exhaust emission standards. The inspection system for an idle mode testing facility should include an exhaust sample handling subsystem and analytical instruments.

Exhaust gases are extremely complex mixtures of hydrocarbons (HC), carbon dioxide (CO_2), carbon monoxide (CO), oxides of nitrogen (NO_x), aldehydes, particulates, water, nitrogen (N), oxygen, hydrogen, and many other compounds. To accurately measure any single pollutant, the application of proper gas sampling techniques and careful sample handling treatment prior to instrument analysis are required. The basic consideration must be to obtain a sample of exhaust gas which is completely representative of the vehicle exhaust for the operating condition of interest.

It becomes necessary to selectively remove those materials and compounds that affect the absolute measurement of the subject pollutant without changing the concentration or characteristics of that pollutant. In a practical sense, this generally means reducing the water vapor level in exhaust gases and filtering out the particulates before passing the gas sample through a measuring instrument. Additionally, the sample handling system must also provide for the periodic input of zero and span check gases and calibration gases.

Sampling System Selection - The sample system for an idle inspection test mode may consist of a tail pipe probe, sample line, vapor condensor, particulate filter(s), sample pump, appropriate valves for the check and calibration cycles, and for purging the system.

The vehicle emission pollutants that require monitoring are:

Carbon Monoxide - The most commonly used method for CO measurement involves the use of a nondispersive infrared (NDIR) instrument. These instruments are based on the principle that the infrared absorption spectrum of CO gas is sufficiently unique, compared to any other exhaust component gases, such that the measurement of infrared energy absorption is proportional to the concentration of the component of interest in the presence of other gases.

Hydrocarbons - The analyses of hydrocarbons in automotive exhaust gas is complicated by two factors; the complex mixture of hydrocarbons and the concentrations of each vary over a wide range. The NDIR technology is the primary method presently in use for hydrocarbon measurements.

Ancillary/Maintenance Equipment - In order to ensure accurate test results, the instruments must be properly maintained and calibrated. The hand tools and digital voltmeter (VOM) used to perform preventive maintenance and minor repairs will cost approximately $1,300.00 per facility. Calibration equipment, that would include five calibration gases and a tachometer calibration, would cost approximately $940.00 per facility.

The exhaust gas analyzer cost estimates in Table 2-2 were developed primarily from interviews with manufacturer's representatives. These interviews focused on identifying the equipment (i.e., type and model) required and the general level of skill needed to operate and maintain each.

In summary equipment costs are as follows:

Analyzer (NDIR) per lane	$2,640.00
Remote tachometer per lane	200.00
Working gas (2% precision) per lane	66.00
Tachometer calibrator per facility	200.00
Calibration gases per facility (1% precision)	740.00
Hand tools per facility	1,300.00
Total	$5,146.00

2.2.1.4 Office Equipment

Office equipment for a two-lane test facility would include two desks and chairs for the supervisor and clerk, two guest chairs, a typewriter, calculator, and two file cabinets. The total cost for each facility would be approximately $1,100 to $3,000 depending upon extent of office furnishings.

2.2.1.5 Computer Costs

Hardware - For each facility, the costs of an automated system (single-processor) are presented in Table 2-3. This approach uses the central computer

TABLE 2-2. ADVERTISED PERFORMANCE SPECIFICATIONS OF EXHAUST GAS ANALYZERS

MODEL	MANUFAC.	OPERATING PRINCIPLE	SPECIFICITY	RANGE	ACCUR.	TEMPERATURE RANGE	HUMIDITY	SAMPLE SYSTEM	INITIAL COST
Mexa 300A	Horiba	NDIR	HC/CO	0-400/2000ppm 0-21/10%	3% FS	32°F to 105°F	95% RH	Filter water separator	$ 2,395
1836	Barnes Eng. Co.	NDIR	HC/CO	0-400/2000ppm 0-2/10%	±3% FS	30°F to 120°F		Filter	2,356
8335C	Barnes Eng. Co.	NDIR	HC/CO	0-400/2000ppm 0-2/10%	±3% FS	30°F to 120°F		Filter	2,494
590	Beckman	NDIR	HC/CO	0-400/2000ppm 0-2/10%	12ppm 0.06%	35°F to 110°F		Filter water trap	2,300
EPA 75	Sun	NDIR	HC/CO	0-500/2000ppm 0-2.5/10%	±2.5% FS	32°F to 120°F		2 filters water trap	2,750
2001	Sun	NDIR	HC/CO misc. computer	0-2000ppm 0-10%	±3% FS			2 filters 2 water traps	17,440
7050C	Autoscan	NDIR thermocouple	HC/CO	0-500/2000ppm 0-2/10%	±2% FS			Filter	2,425
23170	Allen	NDIR	HC/CO	0-500/2000ppm 0-2.5/10%	3% FS			2 filters water traps	2,371
200 Auto-sense	Hamilton Test Systems	NDIR	HC/CO misc. computer	0-2000ppm 0-10%	±3% FS	35°F to 110°F	10% to 90% RH	Filter water trap	16,000
42-076	Marquette	NDIR	HC/CO	0-500/2000ppm 0-2.5/10%	±3% FS	35°F to 110°F	85% RH	Filter water trap	2,425
400	Beckman	FID	Total HC	0-1/10/100/1000ppm	±1&	32°F to 110°F	95% RH	Filter	2,820
951	Beckman	Chemi	NO/NO$_x$	0-10/25-10,000ppm	±0.5% FS				6,200
Mexa 240	Horiba	NDIR	NO/NO$_x$	0-1000/0-4000ppm	±1.0% FS				4,460

Table 2-3. COMPUTER COSTS

1. Equipment per Lane

Item	Number	Estimated Cost ($)
Keyboard Input Device	1	2,000
Test Condition Display	1	2,000
Result Printer	1	2,500
		6,500

2. Data Equipment for each Facility

Item	Number	Estimated Cost ($)
Mini-computer CPU, Internal Memory Operating Controls	1 Syst	6,000-12,000
Input/Output Teletype Paper Tape	1 Syst	3,500- 7,000
Interface/Communications ADC, Multiplexer TTY Line Adapter Data Controllers	1 Syst	7,700
		$17,200-26,700

as an information retrieval and information storage system. Test control, decision processing, and data input/output could be regulated at each facility by a mini-computer as shown in Figure 2-2. The operator would input an identification number to the central computer which would return the description of the vehicle to the operator display, and the test and decision parameters to the site processor. If the description matches the test vehicle, the operator gives his approval to proceed. The site processor maintains control over the test until it is completed. The pass/fail decision would be made by the site processor providing the appropriate outputs both on-site and to the central computer for inclusion in the vehicle's file. The central file is necessary for the mass storage of information on all cars tested.

Software - The central computer would be one of the present on-line systems available in the State of Tennessee. The costs, as established from contact with software companies and past experience, of developing a computer program to provide the input of between 75 to 145 characters per vehicle and a statistical output report are:

- $30 per hour plus a purchased program package at a total cost of approximately $100,000.
- Final operations could be manual or a stand-alone computer system which would provide output data regarding each vehicle that would be forwarded to the central administrative office for processing. Programming cost would be approximately $5,000.

The storage costs of the central computer library would vary in accordance with the motor vehicle listing. The block diagram of such a system is presented in Figure 2-3. The storage cost for the total complement of vehicles in the nonattainment areas would be from $50 to $330 per day. To minimize storage cost, it is necessary to provide for auxillary storage devices (e.g., floppy disk pack). The total storage costs on floppy disks would be approximately $60 per day.

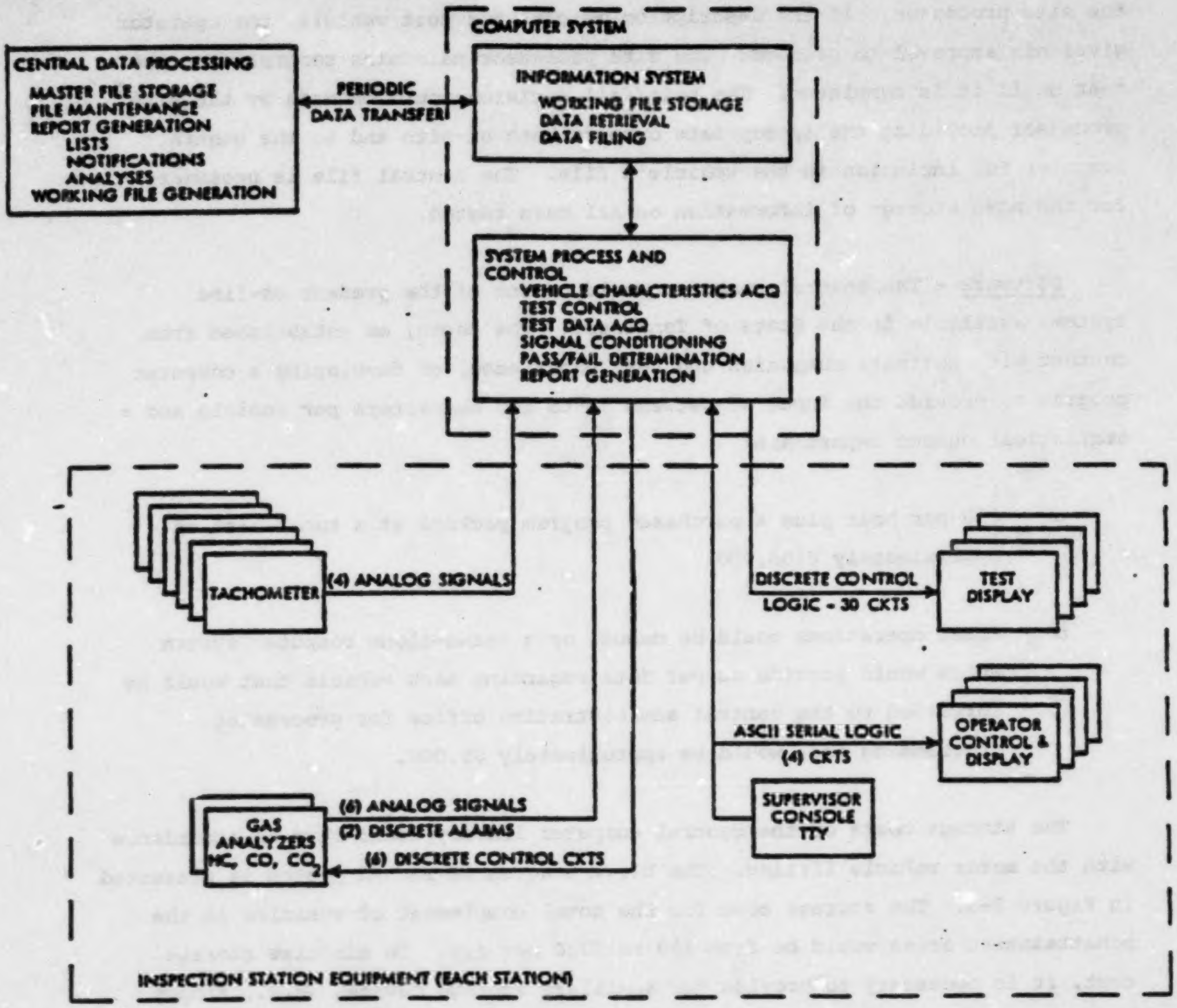
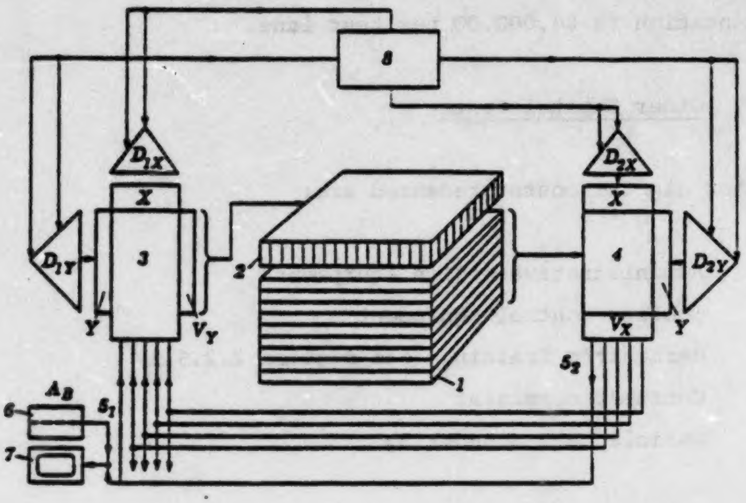

COMPUTER SYSTEM
CENTRAL DATA PROCESSING
MASTER FILE STORAGE
FILE MAINTENANCE
REPORT GENERATION
LISTS
NOTIFICATIONS
ANALYSES
WORKING FILE GENERATION
PERIODIC
DATA TRANSFER
INFORMATION SYSTEM
WORKING FILE STORAGE
DATA RETRIEVAL
DATA FILING
SYSTEM PROCESS AND CONTROL
VEHICLE CHARACTERISTICS ACQ
TEST CONTROL
TEST DATA ACQ
SIGNAL CONDITIONING
PASS/FAIL DETERMINATION
REPORT GENERATION
TACHOMETER
(4) ANALOG SIGNALS
DISCRETE CONTROL
LOGIC - 30 CKTS
TEST DISPLAY
ASCII SERIAL LOGIC
(4) CKTS
OPERATOR CONTROL & DISPLAY
SUPERVISOR CONSOLE TTY
GAS ANALYZERS HC, CO, CO2
(6) ANALOG SIGNALS
(2) DISCRETE ALARMS
(6) DISCRETE CONTROL CKTS
INSPECTION STATION EQUIPMENT (EACH STATION)

Figure 2-2. SYSTEM BLOCK DIAGRAM


8
D_{1X}
D_{2X}
X
X
D_{1Y}
3
4
D_{2Y}
2
Y
V_Y
V_X
Y
1
S_2
A_B
S_1
6
7

Block Diagram for library search; Key 1, the machine memory (library) 2, the address system; 3 and 4, block-step registers; 5, communication channel; 6, station transmitting apparatus; 7 station receiving apparatus; 8, control device, D_X and D_Y decoders; V_X and V_Y output amplifiers.

Figure 2-3. BLOCK DIAGRAM FOR LIBRARY SEARCH

In brief, the an automated system requires an additional $34,950 for a double-lane facility. See Table 2-3 for breakdown of the additional costs.

A summary of the facility costs for a two-lane idle mode station are presented in Table 2-4. The above costs are for the centralized system, state- and contractor-operated, for the decentralized system, private garage-operated, only instrument procurement is necessary. The estimated cost for instrumentation is $4,000.00 per test lane.

2.2.2 Other Capital Costs

Other capital costs presented are:

- Administrative office equipment
- Quality control equipment
- Mechanic's Training (see Section 2.2.5.1)
- Consumer complaint
- Vehicle test scheduling

2.2.2.1 Administrative Office Equipment

The capital costs associated with administrative office equipment (e.g.; desks, chairs, typewriters, bookcases, reference tables, etc.,) is approximately $800 per person.

2.2.2.2 Quality Control Equipment

Mobile Unit - The mobile inspection audit system costs per vehicle are presented in Table 2-5. The mobile inspection system could also be used to:

- Support station operation during station downtime.
- Referee activity in urban areas.

Table 2-4. COST ESTIMATE FOR A NEW ONE POSITION TWO-LANE IDLE-MODE INSPECTION FACILITY (Manual-Operated)

		Base	Unit Factor	Total
1.	**Open Test Area**			
	Raw Land (urban)	16,250 sq. ft.	$ 5.00 sq. ft.[a]	$ 81,250
	Site Preparation	16,250 sq. ft.	$ 1.38 sq. ft.	22,425
	Inner Building (Computer room, office space, locker room, waiting room)	540 sq. ft.	$16.00 sq. ft.	8,640
	Test Area	1,260 sq. ft.	$12.00 sq. ft.	15,120
	Contractor Contingency on Site Work and Building	$46,185	15%	6,928
	Contractor Overhead Profit on Site Work and Building	$46,185	10%	4,618
	Ground Improvement	14,450 sq. ft.	$ 1.20 sq. ft.	17,340
			Subtotal (Item 1)	$156,321
2.	**Equipment**			
	Analyzer (NDIR)	2 req'd	@2,640	5,280
	Calibration gases	5 units	@ 148	740
	Remote TACH	2 req'd	@ 200	400
	Working Gas	2 units	66	132
	TACH Calibrator	1	200	200
	Hand Tools	1	1,300	1,300
			Subtotal (Item 2)	8,052
			TOTAL	$164,373

[a] Source: Tennessee State Planning Division.

Table 2-5. MOBILE UNIT COSTS PER UNIT

EQUIPMENT	COSTS
1. Van	$12,000
2. Van conversion (electrical, cabinets, etc.)	3,000
3. Analyzer (NDIR)	2,540
4. Working gas (2-blend)	66
5. Tachometer	200
6. Gravimetric master gas cylinders (5)	740
7. Tachometer calibrator	200
8 Hand tools	1,000
9. Digital voltmeter	200
Total	$19,946

The calibration check will include a 5-point curve check using 1 percent gravimetric master gases, and correlation tests using the van engine and state-owned analyzers. The State-owned analyzers will have the same capability as the station analyzers. The costs as noted were developed from a dealer survey.

Referee Stations

Customer complaints will arise regarding the reliability of emission test results, especially in cases where a vehicle fails an emission test after the recommended repairs have been performed. In order to resolve complaints of this nature, a referee station can be used. The use of a referee station will also provide an additional check on emission test facility instrumentation, engine diagnosis, and mechanic capability. For customer convenience, as an alternate, the mobile test units could also to be used as a referee station. Upon receipt of a customer complaint and request for verification of emission test results, an appointment will be made to conduct the verification test at the test facility in question.

To avoid an overload on the system, specific criteria will have to be developed to single out complaints for verification testing. For example, vehicles which have failed after the recommended repairs were performed and/or vehicles for which the recommended repair costs are above some predetermined level would be eligible for verification testing.

A sophisticated referee lane with Federal Test Procedure (FTP) capabilities is the unit used in costing in this report. Figures 2-4 and 2-5 presents such a test facility configuration with the third lane as a referee lane. Correlation vehicles could be checked out at this facility. The referee lanes would be set up as a central area relative to the test facilities.

The costs of a referee station capable of FTP testing is presented in Table 2-6. The cost of a referee station without FTP capability, but capable of loaded mode and diagnostic testing is also noted as a minimum system.

Table 2-6. REFEREE STATION EQUIPMENT COSTS

EQUIPMENT	FTP CAPABILITY	MINIMUM SYSTEM (LOAD/DIAG.)
Equipment		
Constant Volume Sample (CVS)	$12,000	
CVS, Calibration Equipment	2,000	
Samples System	5,400	
Dynamometer with road load inertia weights	39,000	$ 16,453
Driver's Aid	5,000	5,000
Cooling fan	650	
Analyzer bench	125,000	16,000
Isolated power for analyzer	3,000	
AC regulators	500	
Gases	8,000	870
Miscellaneous-barometer, wet & dry bulb	8,850	850
Computer FTP	12,000	
SUBTOTAL	$221,400	$ 39,173
Land and Building Cost	$188,456	$188,456
TOTAL	$490,856	$227,629

Correlation Car

In addition to the regularly scheduled calibration checks, correlation vehicles could be used to further standardize the station-to-station equipment complements. The correlation vehicles would be altered in such a way as to reduce to a minimum those variables that would cause variations in the emission levels due to inconsistent energy demands on the engine (e.g., power brakes, air conditioning, fuel composition, fuel temperature, etc.). An emission test performed using a highly standardized correlation vehicle would provide a

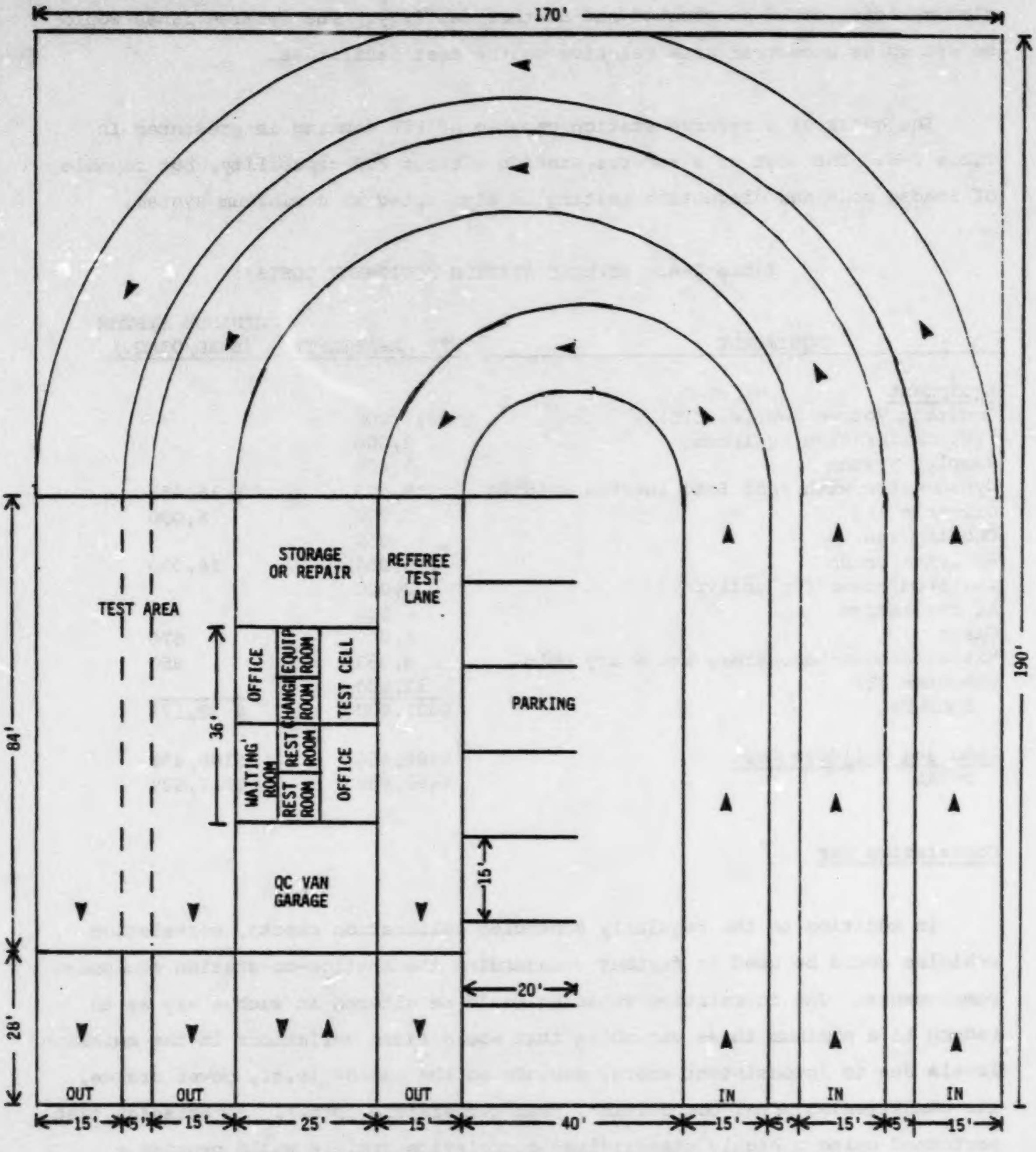

170'
190'
84'
28'
36'
15'
20'
TEST AREA
STORAGE OR REPAIR
REFEREE TEST LANE
OFFICE
EQUIP ROOM
CHANGE ROOM
TEST CELL
WAITING ROOM
REST ROOM
REST ROOM
OFFICE
QC VAN GARAGE
PARKING
OUT
OUT
OUT
IN
IN
IN
15'
5'
15'
25'
15'
40'
15'
5'
15'
5'
15'

Figure 2-4. THREE-LANE/REFEREE FACILITY

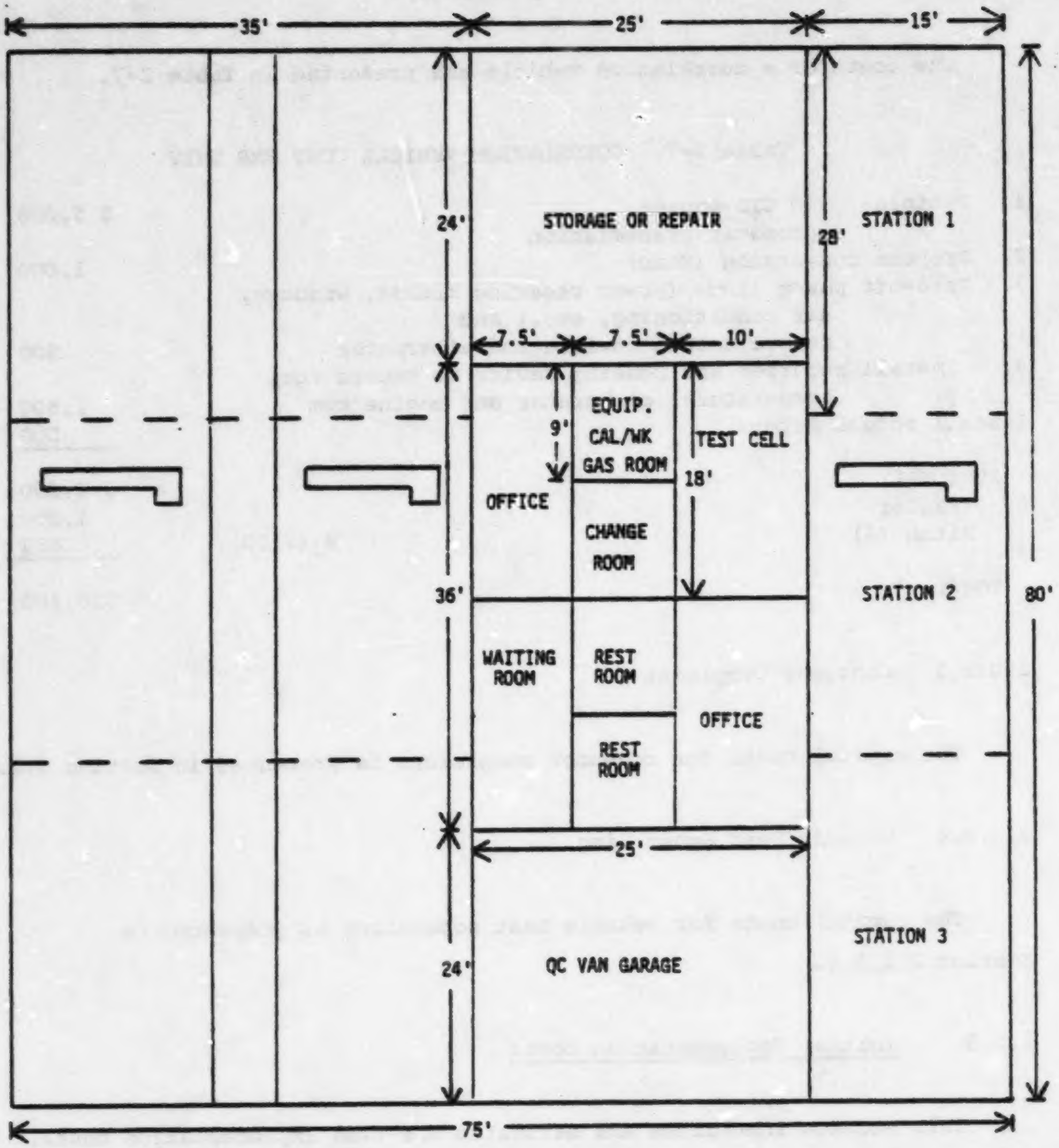

35'
25'
15'
24'
STORAGE OR REPAIR
28'
STATION 1
7.5'
7.5'
10'
EQUIP.
CAL/WK
GAS ROOM
9'
TEST CELL
18'
OFFICE
CHANGE ROOM
36'
STATION 2
80'
WAITING ROOM
REST ROOM
OFFICE
REST ROOM
25'
STATION 3
24'
QC VAN GARAGE
75'

Figure 2-5. INNER OFFICE AND TEST AREA
THREE-LANE/REFEREE FACILITY

quality check on the entire analytic system (i.e.; analyzer, sample collection system, tachometer, and inspection personnel).

The costs of a correlation vehicle are presented in Table 2-7.

Table 2-7. CORRELATION VEHICLE COST PER UNIT

1. Vehicle: 360 CID engine automatic transmission		$ 5,000
2. Propane conversion (Emco)		1,000
3. Take-off power items (power steering brakes, windows, air conditioning, etc.) and remove vacuum advance and alternator		500
4. Install recorder and sensing device to record fuel temperature, carburetor and engine rpm		1,500
Install torque meter		500
SUBTOTAL		$ 8,500
6. Trailer		1,200
7. Hitch (4)	4 ($120)	480
TOTAL		$10,180

2.2.2.3 Consumer Complaint

The capital costs for consumer complaints is presented in Section 2.2.5.3.

2.2.2.4 Vehicle Test Scheduling

The capital costs for vehicle test scheduling is presented in Section 2.2.5.4.

2.2.3 Initial Implementation Costs

This section identifies and estimates one-time implementation costs. Table 2-8 presents cost items within each cost category. It also identifies parties that may share costs.

Table 2-8. ONE-TIME IMPLEMENTATION COSTS

COST ITEMS	STATE	CONTRACTOR[a]	PRIVATE[a]
Site selection	x		N/A
Bids preparation and evaluation	x		N/A
Design of facilities	x	x	N/A
Training plan develement	x		
Personnel selection	x	x	
Document preparation	x		
Administrative support	x		
Initial system certification	x		
System integration and checkout	x	x	x

[a] State will assume cost items not marked.

Site Selection - Costs related to this activity are:

FUNCTION	COSTS
Travel associated with site selection per site.	
Manpower plus travel.	$200 per site
Analysis for optimal site location	
-Consumer convenience	
-Site costs	
-Access	
Analysis for quality control site location	$200 per site
Establish technique for site selection	$5,000
TOTAL	$5,000 + $400 per site

Bids Preparation and Evaluation - Costs were developed for preparation of equipment specifications, reviewing manufacture literature, contacting supplier, and for preparation and review of bid packages.

a. Idle Mode

-Equipment specification	$ 3,000
-Bid package and distribution	2,500
-Bid reviewed and selection	3,750
Total Cost	$ 9,250

b. Computer equipment specification, bid package, preparation, bid review and selection

Total Cost $ 5,500

Design of Test Facilities - The costs for this task is for the structural, architectural, mechanical and electrical design of facilities that meet the requirements of each community. The costs would normally be approximately 5 to 10 percent of construction costs; however, because of continuity of building plans, this is reduced 2-1/2 to 5 percent.

Training Plan Development - Costs are for personnel planning, curriculum development, and class scheduling.

Idle mode $ 3,500

Data were developed from course development in the State of California and from various training centers.

Personnel Selection - Costs are for determining types, qualifications, and quantity of inspection, administrative, and technical personnel required for the program.

Establish Requirements
510 manhours x $15 per hour = $ 7,650
Advertise Personnel Vacancy
40 manhours x $15 per hour = 600
Review and Select Personnel
900 manhours x $15 per hour = 13,500
Advertisment Costs = 14,000
$35,750

Document Preparation - Costs are for clerical, editorial, and reproduction assistance in preparing a document to record the plans, schedules and analytical results associated with the planning and development phase.

Document Preparation
450 manhours x $15 per hour = $ 6,750
Reproduction = 1,000
$ 7,750

Administrative Support - Costs including administrative personnel support tasks during facility construction, equipment purchase, personnel selection, system installation and checkout are:

500 hours x $20 per hour = $10,000

Initial System Certification - Prior to receiving and testing the first vehicle, the entire inspection system must be evaluated and tested to establish conformity to performance specifications. Station certification would consist of a statistical sample vehicle run to ensure satisfactory performance. The costs per station associated for initial system certification by test mode are as follows:

Idle Mode
30 manhours x $15 per hour = $ 450

In general, a 5 percent random sample of stations will be tested.

System Integration and Checkout - System integration involves the interfacing of individual system elements, which may have been procured from different suppliers, and the testing of hardware and software as a total entity to establish compliance with procurement specifications. The average costs per two-lane stations are:

a. For Idle Mode
Test individual equipment
10 hours x $15 per hour = $ 150
Perform integrated test
30 hours x $15 per hour = 450
$ 600

b. For Automated Idle Mode (Additional cost)
Test individual equipment
Test software
20 hours x $20 per hour = $ 400
$ 400

2.2.4 Annual Operating Costs

The annual operating costs of an I/M program include those costs associated with:

- o Test facility operating costs
- o Quality control operation costs
- o Support Costs

These costs consist of the following break outs:

- o Annual test facility operations costs
  - -Personnel costs
  - -Maintenance and miscellaneous items costs
    - a. Utility costs
    - b. Facility maintenance
    - c. Supplies
    - d. Insurance
    - e. Property tax
    - f. Equipment maintenance
- o Quality control operation costs
  - -Administrative supply costs
  - -Mobil unit/maintenance operation costs
    - a. Mobile van
    - b. Referee lanes equipment and building
  - -Correlation vehicle operations costs
    - a. Vehicle maintenance
- o Support costs
  - -Administrative supplies
  - -Administrative office rent
  - -Administrative personnel
  - -Training
  - -Data analyses
  - -Fee collection and vehicle registration processing

- **Consumer Protection Costs**
  - -Mechanic training
  - -Personnel indoctrination and training
  - -Public information programs
  - -Enforcement

For the decentralized system the private garage-operation cost is $13 per hour. This shop rate includes wages and overhead costs*. For the centralized system, state- and contractor-operated, the following subsections provide detailed cost data.

2.2.4.1 Test Facility Operating Costs

Personnel Costs - Annual personnel costs associated with the operation of the inspection facilities are set forth under Section 2.3.1.

Annual Test Facility Maintenance and Miscellaneous Item Costs - Included with these program elements are costs associated with electricity, heat, water building services, insurance, office supplies, inspection forms, etc. These costs were developed from several sources including equipment and facility power requirements equipment manufacturers, the general literature, the prevailing utility rates in the state, average heating requirements data for similar facilities, insurance costs, and general building service requirements from existing programs. The costs per site for all program elements are presented in Table 2-9.

Table 2-9. TEST FACILITY MAINTENANCE, SUPPLIES AND UTILITY COSTS PER 2-LANE IDLE-MODE SITE (Per Year)

COST ITEM	CONTRACTOR	STATE
Facility maintenance	$1,200	$1,200
Supplies	1,000	1,000
Utilities	1,500	1,500
Insurance	1,500	1,500
Taxes	2,500	0
TOTAL	$7,700	$5,200

---

*The average mechanic wage rate is $4.12 per hour, based on information supplied by the State of Tennessee, Planning Department. Overhead was assumed 200%.

The annual equipment operating costs are presented in Table 2-10. These estimates include maintenance costs for both manual and automated systems.

Table 2-10. EQUIPMENT MAINTENANCE COSTS FOR A 2-LANE IDLE STATION (Per Year)

EQUIPMENT[a]	CONTRACTOR	STATE
A. Manual System		
Maintenance	$ 500	$ 500
B. Semi-Automated System Additional Costs		
Computer maintenance		
Total automated costs	$1,850	$1,850
C. Automated System Costs		
Computer costs	$4,045	$4,045

[a] Maintenance costs are established from similar operations as 10 percent of the cost of the equipment.

2.2.4.2 Quality Control Operating Costs

Administrative Supply Costs

Annual supplies for the quality control administration are estimated at $100 per person.

$$S_A = A_p \times (100) + M_p \times (100) + R_p \times (100)$$

$$= \$500 + \$200 \times (\text{\# mobile units}) + \$400 \times (\text{\# referee stations})$$

where:

A_p = administrative personnel
M_p = mobile unity personnel
R_p = referee station personnel

Mobile Unit and Referee Lane Maintenance Operation Costs

Mobile Vans - Annual costs for operations of mobile vans are based upon 25,000 miles per van at \$0.15 per mile and 10 percent of the original equipment costs.

$$M_m = \left[(25{,}000 \times \$0.15) + (4{,}946 \times 0.10)\right] \times \text{\# mobile vans}$$
$$= \$4{,}245 \times \text{\# mobile vans}$$

Referee Lanes - Annual costs for maintenance of referee stations are:

Equipment maintenance - 10 percent of original costs

Building maintenance - \$300 per month = \$3,600 per year per lane

Correlation Vehicle Maintenance Cost - Estimated maintenance cost is 10 percent of the vehicle capital cost.

Personnel Costs - Are presented in Section 2.3.

2.2.4.3 Support Costs

Administration

Supplies - Annual supplies for the administrative personnel are estimated at \$100 per person. For 15 administrative personnel the total cost is computed to be \$1,500.

Office Rent - Annual cost for rental space is \$0.45 per square-foot per month*. The square-foot requirements per person is approximately 150-square feet at a monthly cost per person of \$67.50, or a yearly cost of \$810. For the 15 administrative personnel total yearly cost is estimated at \$12,150.

Personnel Costs - The administrative personnel costs are presented in Section 2.3.

---

*Data provided by the State of Tennessee, Planning Department.

__Data Analyses__ - Emission data collected will have to be reviewed and reports prepared covering various subjects as the State of Tennessee may recommend. Such coverage are:

- Repair cost and status data - (current repairs, emission repairs, etc.)
- Emissions data status HC, CO, and NO as appropriate
- Failure rates
- Warranty failures
- Complaint data
- Recall action
- Vehicle data
- Failure cause
- Retest status
- County status on emissions
- Operations effectiveness

From such a list it appears that monthly, quarterly, or yearly reports would involve a sizeable processing expense. Costs for statistical data processing would be approximately $15,000 to $20,000. The associated cost to formalize the report are:

Technical layout and discussion	$50 per page
Typing and editing	$7 per page
Printing and collating	$0.10 per page

A 250-page report would cost $15,500 for preparation and publishing 50 reports. Total cost for complete quarterly reports with all noted items would be approximately $30,000 to $35,000 per report. This could be reduced by publishing one major report with quarterly supplements. Thus, annual cost would be approximately $45,000.

__Fee Collection and Vehicle Registration__ - The fee collection cost would be negligible after initial implementation costs if they were integrated into the vehicle registration costs.

Training - Personnel training is a continuing process. It is required to:

- Indoctrinate/train new and replacement personnel
- Upgrade inspection personnel in new techniques and automotive changes.

The costs noted here are for continuing instruction only, and costs are estimated as $100 per employee per year plus $250 per year for 15 percent of the employees, assuming a 15 percent termination rate.

2.2.5 Consumer Protection Costs

This section presents estimated start-up and operating expenditures for mechanic training, public information, and enforcement programs. Each program element will take advantage of existing state resources in the form of personnel services, equipment, and procedures. This will reduce the initial cost burden to institute needed consumer protection measures.

The organization of this section consists of four major subsections that separately examine consumer protection program elements. These subsections are arranged as follows:

- Mechanic training program
- Public information program
- Complaint follow-up
- Test scheduling and fee collection

2.2.5.1 Mechanic Training

In order to develop costing data for starting a mechanic training program, it was necessary to calculate the minimum number of mechanics required to support emission repair activity.

It is estimated that 0.95 million vehicles will require emission testing on an annual basis. Assuming a 30 percent failure rate, 0.29 million vehicles will require some form of maintenance before reinspection. If 39 percent of all emission repairs are performed by "do-it-yourself" (Ref. 1), then 0.18 million vehicles will be serviced by certified emission mechanics. The minimum number of mechanics required to service failed vehicles is calculated as follows:

$$
\begin{aligned}
\#\text{vehicles serviced/mechanic/year} &= (8\text{ hrs/day})(1\text{ vehicle/1.54 hrs}) \\
&\quad (5\text{ days/wk})(50\text{ wks/yr}) \\
&= 1{,}299\text{ vehicles/yr}
\end{aligned}
$$

Here, 1 vehicle/1.54 hour is based upon the following assumption as obtained from private repair garage survey (Ref. 35). Average repair cost was $33.00 and labor cost was $21.50 per hour. Therefore, time per repair was estimated as:

$$\frac{\$33/\text{repair}}{\$21.50/\text{hour}} = 1.54\text{ hours per repair.}$$

Assuming a 85 percent manpower efficiency, the actual number of vehicles serviced per year is calculated as 1,104 vehicles. Therefore, the estimated number of mechanics required is calculated as follows:

$$
\begin{aligned}
\#\text{ mechanics required} &= \frac{0.18 \times 106\text{ vehicles/year}}{1{,}104\text{ vehicles/mechanic/year}} \\
&= 163\text{ mechanics}
\end{aligned}
$$

The emission repair work will occupy from 10 to 100 percent of the total work burden, therefore, the number of mechanics required to support the I/M program is 163 to 1,630 mechanics (see Figure 2-6).

The program costs, and other relevant information, for training these mechanics are shown in Table 2-11. These costs were developed by assuming that at least 30 mechanics would enroll in each class for programs administered by state vocational instructors.

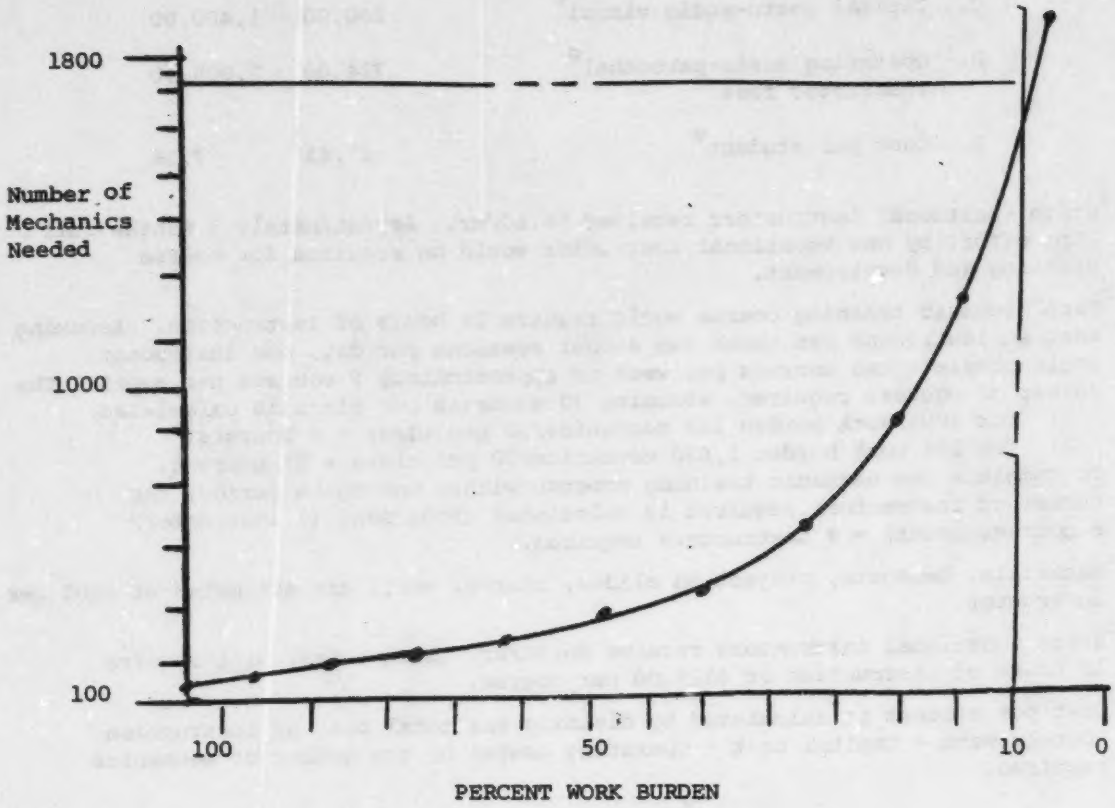


Figure 2-6. MECHANICS NEEDED VERSUS WORK BURDEN

Table 2-11. ESTIMATED PROGRAM COSTS FOR MECHANIC TRAINING

COST CONSIDERATIONS	COST RANGE From	COST RANGE TO
A. Personnel planning, curriculum[a] development and class scheduling	3,500.00	3,500.00
B. Instructors required[b]	1	7
C. Capital costs-audio visual[c]	200.00	1,400.00
D. Operating costs-personnel[d] Instructor fees	774.00	7,095.00
E. Cost per student[e]	27.45	7.36

[a] State vocational instructors received $6.80/hr. Approximately 3 months full time effort by one vocational instructor would be required for course planning and development.

[b] Each mechanic training course would require 19 hours of instruction. Assuming that an instructor can teach two 4-hour sessions per day, one instructor could complete two courses per week or approximately 8 courses per month. The number of courses required, assuming 30 students per class is calculated:
1) for 100% work burden 163 mechanics/30 per class = 6 courses.
2) for 10% work burden 1,630 mechanics/30 per class = 55 courses.
To complete the mechanic training program within one month period, the number of instructors required is calculated (#courses) (1 instructor/ 8 courses/month) = # instructors required.

[c] Materials, handouts, projection slides, charts, etc., are estimated at $200 per instructor.

[d] State vocational instructors receive $6.80/hr. Each course will require 19 hours of instruction or $129.00 per course.

[e] Cost per student is calculated by dividing the total cost of instruction (Development + Capital cost + Operating costs) by the number of mechanics required.

The above costs can be defrayed by charging a tuition of approximately $8 to $28 per student. This can be allocated to pay instructor fees, capital costs (audio visual materials, and maintenance upkeep, etc.).

2.2.5.2 Public Information Programs

To estimate the costs associated with a public information program, most states with experience in I/M public information programs were contacted. From contacts and additional research, a full range of possible activities was established and basic cost figures derived (Table 2-12). It is important to realize that the range of possible activities and comprehensiveness of public information programs varies considerably.

There are essentially two program elements that are widely used as I/M public information techniques. One element is the use of radio and television public service announcements, and newspaper advertisements. A second technique is the development of an information phamplet that is mailed, along with vehicle registration form to vehicle owners.

To subsidize an initial and ongoing I/M public information program; it has been estimated that $0.25 per vehicle would generate revenues in excess of $200 thousand. These funds would finance various different combinations of informative programming as set forth in Table 2-12.

2.2.5.3 Complaint Follow-Up

Consumer Affairs - Two major support services provided by the consumer affairs office would involve complaint follow-up, and service industry field check. Annual cost estimates in providing such services are shown in Table 2-13. Estimated cost data include only major program considerations such as computer time sharing, personnel, investigative services, etc.

The California Air Resources Board (ARB) conduct service warranty field investigations to ensure that new and used car dealers have not tampered with the emission control devices. It is estimated that over 6,000 vehicles are

Table 2-12. INITIAL/ONGOING PUBLIC INFORMATION PROGRAM FOR ONE YEAR[a]

PROGRAM TYPE	COST DESCRIPTION
A. ADVERTISEMENTS	
1. Public Service Announcements	
Newspaper	Full page advertisement 172-inch @ 1.65 per inch.
Television	1-minute public service announcements @ $40 per 10-second or $240 per minute.
Radio	1-minute service announcements @ $200 per minute includes radio and commission.
2. Pamphlet	
Development/preparation	Artist (logo and cover design) plus commission @ 20 hours.
Printing	Pamphlet printed on 20 lb paper, 1 color, foldout 7-1/2" x 11" (6 million copies).
3. Bumper Sticker	Printed on 6 lb all weather paper, 1 color.
4. Transit aids	Space cost on 35 buses, $102 per month per bus (both sides).
B. PRESENTATIONS	
1. Films	Film development (30-minute information film).
2. Slide Shows	Slide show development $500.
3. Guest Speakers	Use of existing public relations personnel minimizes cost.

[a] Source: Telephone contacts to various advertisement agencies, publishing houses, and printers.

Table 2-13. CAPITAL/OPERATING COSTS ASSOCIATED WITH CONSUMER COMPLAINT FOLLOW-UP AND SERVICE INDUSTRY FIELD CHECK

COST CONSIDERATIONS	COSTS[a]	COSTS[b]
1. Capital		
(3) Complaint inspection cars		$15,000
2. Operating Cost (per year)		
a. Computer time sharing[c] 24 hrs. @ $475.00/hr. Other computer services - 20% of the computer costs	$13,700	
b. Personnel		
3 field investigators[d]	38,000	
1 statistician	10,000	
3 clerks	24,000	
c. Vehicular		
gas/oil	3,000	
insurance	1,000	
SUBTOTAL	$89,700	$15,000

[a] Over a 1-year period.

[b] One time initial cost.

[c] Batch time sharing plus analyses.

[d] Minimum personnel required for handling consumer complaints over the telephone and investigating at $900/month salary and 17 percent benefits.

checked each year prior to sale. In addition, the ARB also conduct field investigations of individual vehicle owner emission control warranty complaints, this amounts to another 250 field investigations per year. The 250 field investigations, account for only a small portion of the complaints received, all of the remaining complaints are resolved over the telephone. To accomplish these tasks, the ARB has 9 field investigators (Ref. 53).

In addition to the California's experience, in order to estimate program costs, it was necessary to make the following assumptions:

- Ten percent of the vehicles that initially failed the emission test (30 percent) would fail the after maintenance retest.

  $(0.10) \times (0.30) \times (.95 \times 10^6) = 28{,}500$ vehicles (Ref. 54).

- Owners of those vehicles that fail the after maintenance retest would be the most likely to file complaints, therefore, there would be 28,500 possible complaints per year.

- Based on ARB's experience, most complaints could be resolved over the telephone by field investigators. For this study it is assumed that 90 percent would be resolved over the telephone; therefore, there would be $0.1 \times 28{,}500 = 2{,}850$ possible unresolved complaints per year.

Based on the above assumptions, it is estimated that three field investigators would be sufficient to handle the telephone resolvable complaints and to direct the unresolved complaints to the appropriate referee stations for further investigation.

2.2.5.4 Vehicle Test Scheduling Costs

Table 2-14 enumerates capital and operating cost expenditures associated with vehicle notification, vehicle scheduling, etc. Capital expenditures would include only software development, since existing computer services would be utilized. Computer software includes programming time, batch processing, etc. Operating costs include processing registration files, computer time, vehicle owner notification and postage.

Table 2-14. ASSUMED COST EXPENDITURES FOR VEHICLE TEST SCHEDULING

COST CONSIDERATIONS	COST	
A. Capital Expenses[a]		
Software development		$ 67,000
B. Annual Operating Expenses (Per Year)[b]		
Processing files 4,800 manhours x $20/hr	96,000	
Computer time 5 hrs x $475/hr	2,375	
Notification, IBM cards 0.95 million cards	119,000	
Postage $0.08/notification	80,000	
Subtotal =	$ 297,375	$ 67,000

[a] Implementation cost only.

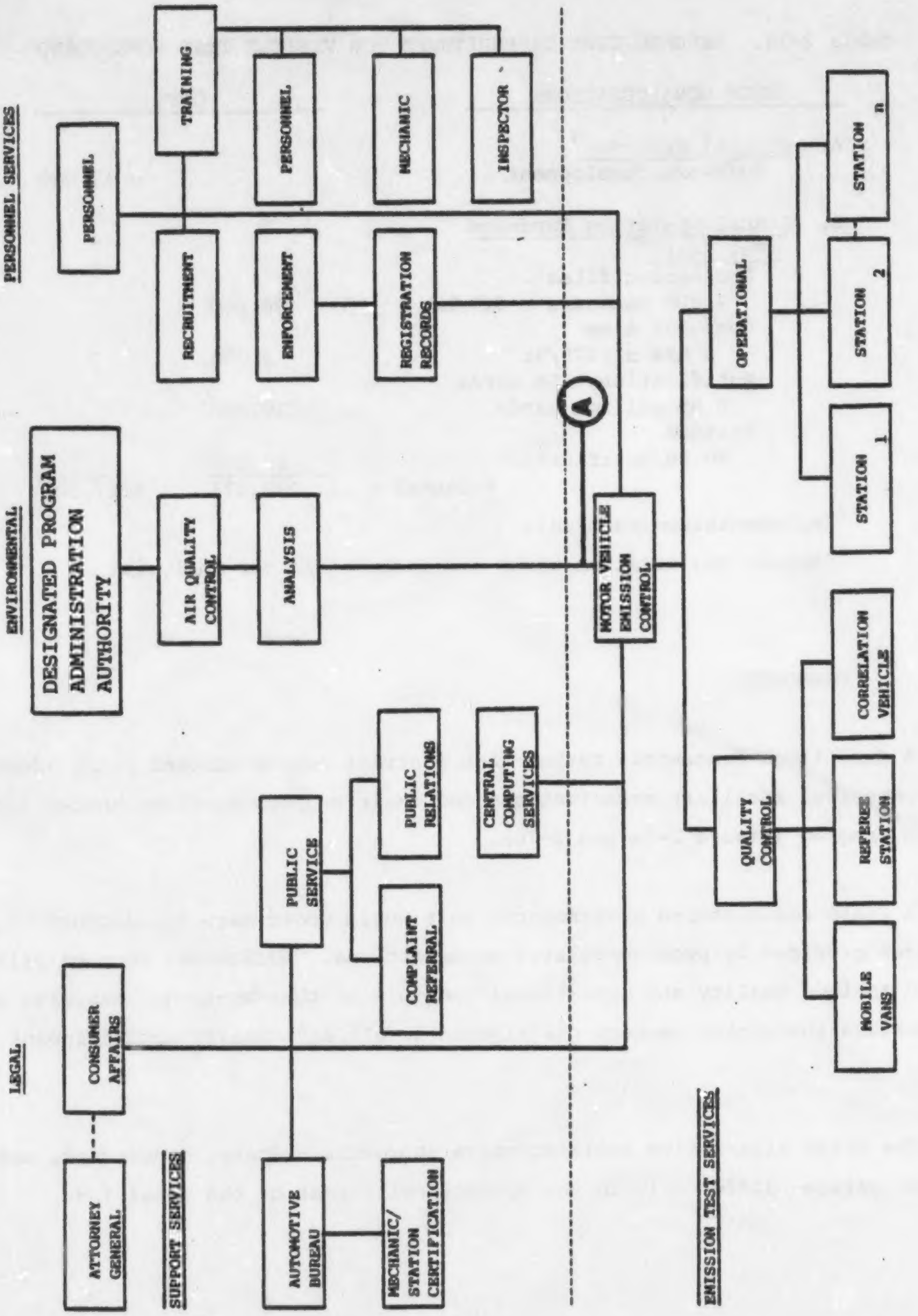
[b] Vehicle registration costs are included in our analysis.

2.3 PERSONNEL

A functional framework, rather than a strict organizational plan, identifies potneital ancillary organizations and their support services needed for an I/M program (Figure 2-7a and 2-7b).

A State-administered governmental unit would coordinate all support services provided by program-related organizations. Additional responsibilities should include quality and operational controls of the day-to-day business of the various inspection centers distributed in all air quality nonattainment areas.

The three alternative administrative approaches--state, contractor, and private garage--differ only in the operational format of the total I/M



LEGAL
ATTORNEY GENERAL
CONSUMER AFFAIRS
SUPPORT SERVICES
AUTOMOTIVE BUREAU
MECHANIC/ STATION CERTIFICATION
PUBLIC SERVICE
COMPLAINT REFERRAL
PUBLIC RELATIONS
CENTRAL COMPUTING SERVICES
ENVIRONMENTAL
DESIGNATED PROGRAM ADMINISTRATION AUTHORITY
AIR QUALITY CONTROL
ANALYSIS
PERSONNEL SERVICES
PERSONNEL
RECRUITMENT
TRAINING
ENFORCEMENT
PERSONNEL
REGISTRATION RECORDS
MECHANIC
INSPECTOR
A
MOTOR VEHICLE EMISSION CONTROL
EMISSION TEST SERVICES
MOBILE VANS
QUALITY CONTROL
REFEREE STATION
CORRELATION VEHICLE
OPERATIONAL
STATION 1
STATION 2
STATION n

Figure 2-7a. Functional Administrative Chart

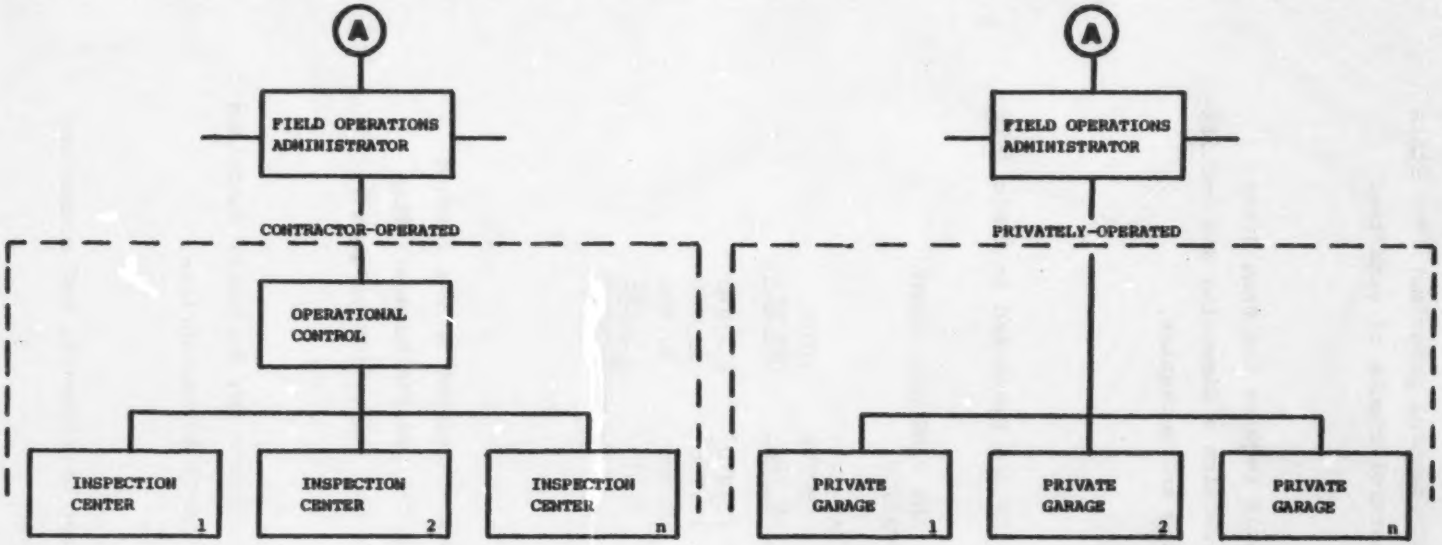

A
FIELD OPERATIONS ADMINISTRATOR
CONTRACTOR-OPERATED
OPERATIONAL CONTROL
INSPECTION CENTER 1
INSPECTION CENTER 2
INSPECTION CENTER n
A
FIELD OPERATIONS ADMINISTRATOR
PRIVATELY-OPERATED
PRIVATE GARAGE 1
PRIVATE GARAGE 2
PRIVATE GARAGE n

Figure 2-7a. County Administered

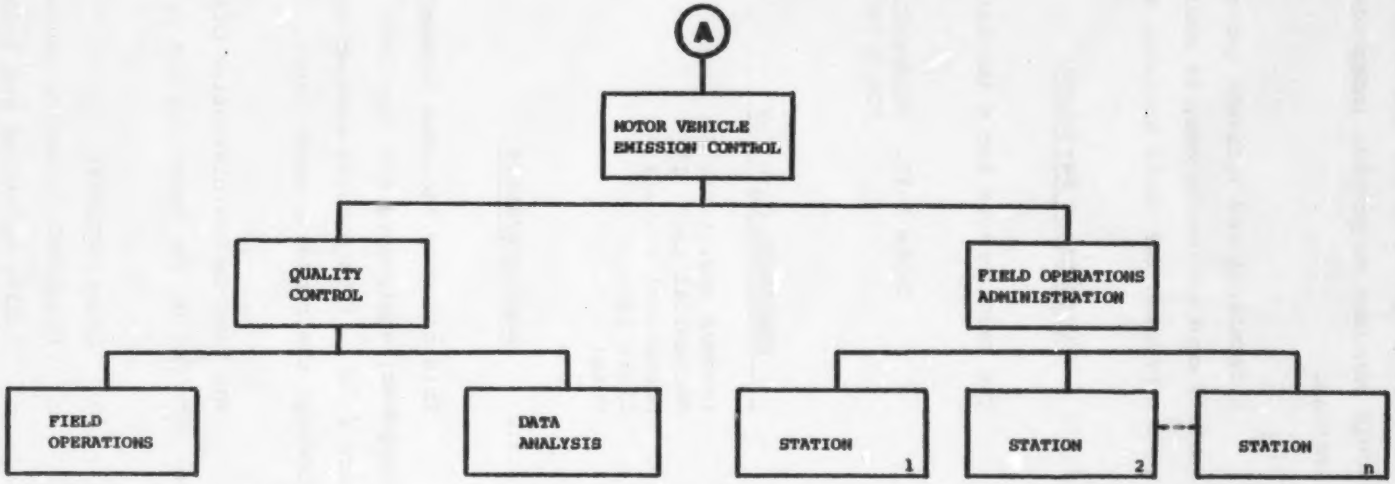

A
MOTOR VEHICLE EMISSION CONTROL
QUALITY CONTROL
FIELD OPERATIONS
DATA ANALYSIS
FIELD OPERATIONS ADMINISTRATION
STATION 1
STATION 2
STATION n

Figure 2-7b. Modifications to Reflect Contractor Decentralized (Private Garage) System and County Administered System

framework. (For instance, a contractor-owned/operated program (Figure 2-7b) could be responsible for its own in-house quality control program.) The State would continue to provide independent quality control checks of each test station.

A decentralized (private garage) system would require the same State quality control checks but, in addition, would require a licensing and certification program for their emission test facilities and mechanics.

2.3.1 Operations Personnel

The requirements for a two-lane test facility are presented in Table 2-15.

Table 2-15. PERSONNEL REQUIREMENT AND PERSONNEL COSTS FOR A TWO-LANE IDLE STATION

PERSONNEL CATEGORY	NUMBER REQUIRED	SALARY + BENEFITS PER YR.	TOTAL PER YR.
Leadman eng. tech. II	1	$12,870	$12,870
Mechanical tech. II	2	10,730	21,460
Mechanical tech. I	2	10,300	20,600
Clerk II	1	8,240	8,240
Total			$63,170

2.3.2 Administrative

This category includes primarily administrative support in the form of manpower, equipment, and supplies. There is one I/M program manager (Figure 2-7a). This program manager will administer the inspection program through the regional supervisors.

The Program Administrative Office would coordinate the following functions as provided by the Tennessee EPA or other departments as appropriate.

- Legal activity
- Financial including purchasing, contract development, and accounting
- Public relations and information program
- Technical reports development

- Mechanics training
- Operations and administrative personnel training
- Consumer complaint
- Fee collection and vehicle owner notification
- Certification/licensing of mechanics

The personnel required and annual costs are presented in Table 2-16. The administrative personnel include the Office Manager and staff, the Quality Control Supervisor and staff, and the Operational Control Supervisor and staff.

2.3.3 Quality Control Field Support

In addition to the administrative quality control staff, the quality control section would require the field personnel complement presented in Table 2-17.

The mobile quality audit personnel requirements are necessary to provide the following service:

- Quality control audit of each station at least once every 3 months.

The following methodology was used to establish personnel requirements:

- A minimum of four stations would be checked per day. This is based upon 1/2-hour test time and 1-1/2 hours travel time per station.

- Each mobile unit requires:
  -One lead instrument technician
  -One support technician.

- The number of mobile quality control units would depend upon the number of test facilities required to service the vehicles for the various options.

Table 2-16. ADMINISTRATIVE PERSONNEL REQUIREMENTS AND YEARLY COSTS

PERSONNEL CATEGORY	NUMBER REQUIRED	SALARY + 17% BENEFIT FACTOR	TOTAL
Program Administrator	1	$20,150	$20,150
Secretary (Clerk Typist III)	1	8,790	8,790
Clerk I	2	7,300	14,600
Environmental Engineer II	1	12,770	12,770
Statistical Analyst	1	12,770	12,770
Assistant Program Administrator (QC)	1	$16,380	$16,380
Environmental Engineer II	1	12,770	12,770
Clerk - Typist I	2	7,300	14,600
Statistical Analyst	1	12,770	12,770
Assistant Program Administrator (Testing)	1	$16,380	$16,380
Clerk - Typist I	2	7,300	14,600
Environmental Engineer II	1	12,770	12,770

Administrative Total - $169,350

Table 2-17. QUALITY CONTROL FIELD PERSONNEL PER UNIT BASIS PER YEAR

PERSONNEL CATEGORY	NUMBER REQUIRED	SALARY + 17% BENEFIT FACTOR	TOTAL
Mobile Control Unit (Per Unit)			
Lead technician (instrument) II	1	$ 9,690	$ 9,690
Technician I	1	8,780	8,780
Total			$18,470
Referee Station (per unit)			
Environmental engineer II	1	$16,620	$16,620
Diagnostic mechanic V	1	10,710	10,710
Test technician (instrument)	1	10,130	10,130
Clerk - Steno I	1	9,080	9,080
Total			$46,540
Correlation Vehicle	No additional manpower required. This unit would be a part of the mobile quality control audit team.		

The quality control referee lane is required to provide the following services:

- To investigate consumer complaints.
- To institute development practices to improve operation effectiveness.
- To provide a supplementary lane for overflow and support queuing problems.
- To initiate new practices related to new control devices.
- To provide a diagnostic routine for establishing repair effectiveness and special problem review.
- The referee station could be capable of performing mass emissions testing.
- The referee station could be capable of diagnostic testing.

The correlation vehicle could be a part of the mobile quality control audit units. It would be used to establish correlation characteristics from station to station, and to support the quality control audit of problem stations.

Total personnel cost for quality control methodology.

$$Q_c^p = \sum A_m^c + M_m^c \,.\, \# \text{ units} + R_m^c \ (\# \text{ referee station})$$

$$= 56{,}500 + 18{,}470 \ (\# \text{ units}) + 46{,}540 \ (\# \text{ referee station})$$

where:

A_m^c = administrative quality control personnel cost per year

M_m^c = mobile quality control personnel cost per year

R_m^c = referee lane quality control personnel cost per year

2.3.4 Support Personnel

Support services are required from the following areas:

- Environmental Protection Agency (emissions analysis and yearly report activities).
- Consumer Affairs Office.
- Attorney Generals Office
- Public Relations Department
- Computer Services
- Personnel Department
  - -Recruitment
  - -Training service
- Mechanic Training

The support service costs are presented in Table 2-18.

2.4 SENSITIVITY OF COSTS TO LANE REQUIREMENTS PER STATION

Cost data developed in Sections 2.2 and 2.3 were based on double-lane configuration. Other types of lane configuration, such as single-, three-, four-, five-, and six-lane were studied. Sensitivity of costs with respect to these configurations are presented in Tables 2-19 through 2-23.

In these tables, all costs are normalized to double-lane configuration. Thus, actual costs of other lane configurations can be obtained by multiplying these "scale factors" by the double-lane costs. The facility operating costs are on the basis of per-station, while scale factors of other cost categories are on the basis of total cost as noted.

Table 2-18. SUPPORT SERVICE COSTS

SUPPORT SERVICE	OPERATIONS COSTS	PERSONNEL COSTS
Analysis - yearly report	Ref. Section 2.2.4.3	Included in operations costs
Consumer affairs	Ref. Section 2.2.5.3	Included in operations costs
Attorney general[a]	$15,000 per year	Included in operations costs
Public information	Ref. Section 2.2.5.2	1 person 25% of time at a cost of $750/month
Central computer service	Ref. Section 2.2.1.5	Included in operations costs
Personnel[b]	$300/new hire	Included in operations costs
-recruiting	1. 0.15 x # personnel x $125	
-training	2. # personnel x $50	
Mechanics training	Ref. Section 2.2.5.1	Included in operations costs

[a] Seven referrals per year; each referral would require approximately 2 days of activity with one court appearance in 2 years - attorney cost are $200/day + court costs for a total cost of $15,000/year.

[b] 15% personnel turnover and $50 per personnel continuing training.

Table 2-19. NORMALIZING FACTORS FOR CONSTRUCTION COSTS (PER STATION)

COST ITEMS	NUMBER OF TEST LANES					
	Single	Double	Three	Four	Five	Six
1. Land and off-/on-site improvement[a]	.85	1	1.15	1.30	1.45	1.60
2. Facility construction[a]	.8	1	1.25	1.50	1.75	2.0
3. Instrumentation[b]	.5	1	1.5	2	2.5	3
4. Office equipment[a]	1	1	1.2	1.3	1.4	1.5
5. Computer[c]	1	1	1	1	1	1

[a] Cost of land and improvements and facilities have a fixed cost and a variable cost. The variable cost is related to the number of vehicles handled.

[b] Instrumentation costs are directly related to number of lanes.

[c] Computer capital costs will not change. However, there may be some delay in access as a result of the increased demand.

Table 2-20. NORMALIZING FACTORS FOR OTHER CAPITAL COSTS (TOTAL COSTS)

COST ITEMS	NUMBER OF TEST LANES					
	Single	Double	Three	Four	Five	Six
1. Administrative office equipment	1	1	1	1	1	1
2. Quality control eqiupment[a]	1.75	1	.8	.7	.64	.6
3. Enforcement	1	1	1	1	1	1
4. Mechanic training	1	1	1	1	1	1
5. Public information	1	1	1	1	1	1

[a] Quality control requirements vary because of the increase or decrease in travel time.

Table 2-21. NORMALIZING FACTORS FOR INITIAL IMPLEMENTATION COSTS (TOTAL COSTS)

COST ITEMS	NUMBER OF TEST LANES					
	Single	Double	Three	Four	Five	Six
1. Site selection[a]	1.5	1	.84	.75	.70	.67
2. Bids preparation and evaluation[a]	1.5	1	.84	.75	.70	.67
3. Design facilities[a]	1.5	1	.84	.75	.70	.67
4. Training plan development	1	1	1	1	1	1
5. Personnel selection	1	1	1	1	1	1
6. Document preparation	1	1	1	1	1	1
7. Administrative support[a]	1.5	1	.84	.75	.70	.67
8. System certification[b]	1.75	1	.8	.7	.64	.6
9. System integration and checkout[b]	1.75	1	.8	.7	.64	.6

[a] Variation of cost is the result of increase/decrease of facility requirements.

[b] Variation of cost is the result of travel to test time relation of facilities.

Table 2-22. NORMALIZING FACTORS FOR FACILITY OPERATING COSTS (PER STATION)

COST ITEMS	NUMBER OF TEST LANES					
	Single	Double	Three	Four	Five	Six
1. Facility Operation						
a. facility personnel	.67	1	1.5	1.84	2.34	2.67
b. facility maintenance, utility, service, and supplies	.67	1	1.5	1.84	2.34	2.67
2. Support						
a. administration	1	1	1	1	1	1
b. data analyses	1	1	1	1	1	1
c. training	1	1	1	1	1	1
3. Quality Control						
a. administrative supply	1	1	1	1	1	1
b. maintenance	1	1	1	1	1	1

Table 2-23. NORMALIZING FACTORS FOR CONSUMER PROTECTION COSTS (TOTAL COSTS)

COST ITEMS	NUMBER OF TEST LANES					
	Single	Double	Three	Four	Five	Six
1. Mechanic Training	1	1	1	1	1	1
2. Public Information Program	1	1	1	1	1	1
3. Enforcement	1	1	1	1	1	1

2.5 GEOGRAPHIC AREA AND AIR QUALITY

Recently, the Tennessee Environmental Protection Agency had identified 4 counties as air quality nonattainment areas. Specifically, they are Davidson, Shelby, Hamilton, and Knox Counties (Figure 2-8). Ozone levels of these counties have exceeded their national standard. As to CO, three counties (Shelby, Davidson, and Knox) have been designated as nonattainment areas (Figure 2-9). All counties in Tennessee have retained their attainment status relative to NO_2 standard (Ref. 52).

The cost and benefit analyses was done for the four nonattainment counties designated by the State of Tennessee, Figure 2-9.

2.6 VEHICLE PROJECTIONS

It was necessary to estimate the vehicle population projections, as presented in Table 2-24, from the vehicle miles traveled (VMT) data supplied by the State of Tennessee (Ref. 52). For reference, the VMT data are included in Appendix G. The following methodology was used to estimate the vehicle population.

$$V_p = \frac{VMT_f}{VMT_t} \times V_m \times V_t$$

V_p = Vehicle population
VMT_f = Vehicle miles of travel, functional classification
VMT_t = Vehicle miles of travel, total
V_m = Vehicle mix
V_T = Total vehicles owned.

Population data for LDV, LDT, and LDT_2 was used as a data base for cost analysis.

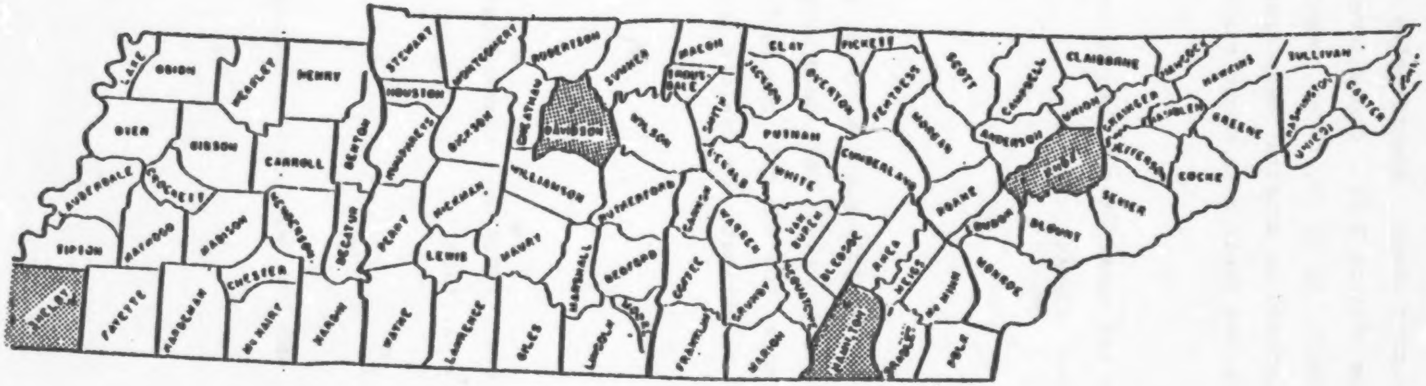
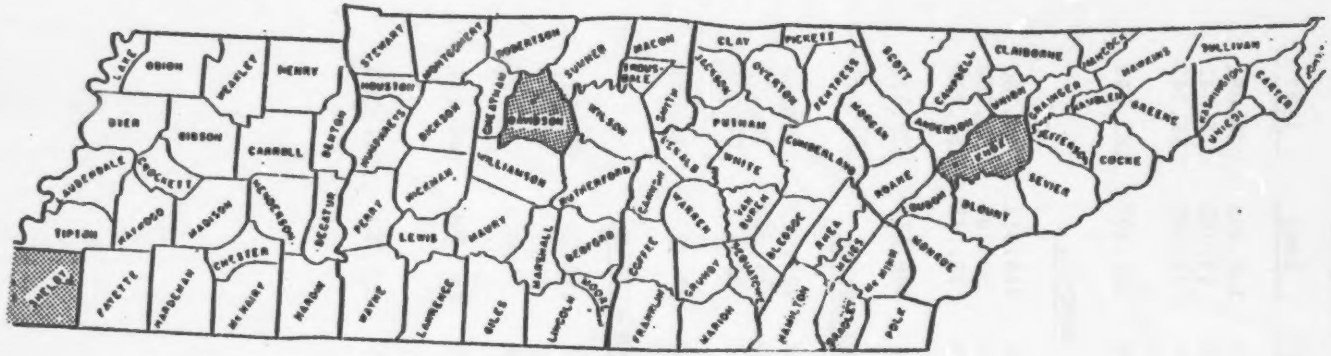

LAKE
OBION
WEAKLEY
HENRY
STEWART
MONTGOMERY
ROBERTSON
SUMNER
MACON
CLAY
PICKETT
SCOTT
CAMPBELL
CLAIBORNE
HANCOCK
HAWKINS
SULLIVAN
JOHNSON
DYER
GIBSON
CARROLL
BENTON
HOUSTON
HUMPHREYS
DICKSON
CHEATHAM
DAVIDSON
TROUSDALE
WILSON
SMITH
JACKSON
OVERTON
FENTRESS
MORGAN
PUTNAM
UNION
ANDERSON
GRAINGER
HAMBLEN
GREENE
WASHINGTON
CARTER
UNICOI
LAUDERDALE
CROCKETT
HAYWOOD
MADISON
HENDERSON
DECATUR
PERRY
HICKMAN
WILLIAMSON
RUTHERFORD
DE KALB
CANNON
WHITE
CUMBERLAND
ROANE
KNOX
JEFFERSON
COCKE
SEVIER
BLOUNT
LOUDON
TIPTON
SHELBY
FAYETTE
HARDEMAN
CHESTER
MC NAIRY
HARDIN
WAYNE
LEWIS
MAURY
LAWRENCE
GILES
MARSHALL
BEDFORD
LINCOLN
MOORE
COFFEE
FRANKLIN
WARREN
VAN BUREN
GRUNDY
SEQUATCHIE
MARION
BLEDSOE
RHEA
MEIGS
MC MINN
MONROE
HAMILTON
BRADLEY
POLK

Figure 2-8. TENNESSEE COUNTIES NONATTAINMENT FOR OZONE



LAKE
OBION
WEAKLEY
HENRY
STEWART
MONTGOMERY
ROBERTSON
SUMNER
MACON
CLAY
PICKETT
SCOTT
CAMPBELL
CLAIBORNE
HANCOCK
HAWKINS
SULLIVAN
JOHNSON
DIER
GIBSON
CARROLL
BENTON
HOUSTON
HUMPHREYS
DICKSON
CHEATHAM
DAVIDSON
WILSON
TROUS-DALE
SMITH
JACKSON
OVERTON
FENTRESS
PUTNAM
MORGAN
ANDERSON
UNION
GRAINGER
HAMBLEN
GREENE
WASHINGTON
CARTER
UNICOI
LAUDERDALE
CROCKETT
HENDERSON
DECATUR
PERRY
HICKMAN
WILLIAMSON
RUTHERFORD
DEKALB
WHITE
CUMBERLAND
ROANE
KNOX
JEFFERSON
COCKE
SEVIER
BLOUNT
LOUDON
TIPTON
HAYWOOD
MADISON
LEWIS
MAURY
MARSHALL
BEDFORD
CANNON
WARREN
VAN BUREN
BLEDSOE
RHEA
MEIGS
MC MINN
MONROE
SHELBY
FAYETTE
HARDEMAN
CHESTER
MC NAIRY
HARDIN
WAYNE
LAWRENCE
GILES
LINCOLN
MOORE
COFFEE
FRANKLIN
GRUNDY
SEQUATCHIE
MARION
HAMILTON
BRADLEY
POLK

Figure 2-9. NONATTAINMENT COUNTIES FOR CO

Table 2-24. VEHICLE POPULATION PROJECTIONS

	1977	1982	1987
CHATTANOOGA			
LDV	91,352	105,095	129,863
LDT$_1$	11,778	13,551	16,743
LDT$_2$	11,778	13,551	16,743
Total	114,908	132,197	163,349
MEMPHIS			
LDV	295,961	326,611	358,180
LDT$_1$	27,714	30,783	33,758
LDT$_2$	27,729	30,765	33,738
Total	351,404	388,159	425,676
NASHVILLE			
LDV	196,338	223,017	258,236
LDT$_1$	21,625	24,501	28,209
LDT$_2$	20,087	22,752	26,206
Total	238,050	270,270	312,651
KNOXVILLE			
LDV	108,620	118,630	128,623
LDT$_1$	7,335	8,040	8,749
LDT$_2$	7,324	8,030	8,735
Total	123,279	134,700	146,107
GRAND TOTAL	827,641	925,326	1,047,783

2.7 TEST MODE

2.7.1 Idle-Mode Test

The idle-mode test is the test of the exhaust emissions with the vehicle in a neutral gear and the engine at idle. Often, hydrocarbon (HC) and carbon monoxide (CO) levels are recorded at both normal and high idle speed. The test at the normal idle speed is taken at the manufacturer's recommended idle, measured in revolutions per minute (rpm), and then the engine speed is increased to 2,500 rpm for the high idle speed test.

The overall test procedure includes the following steps: 1) collection of vehicle identification data (year, make, model, license number, vehicle identification number, etc.); 2) visual inspection of the exhaust system and emission control devices; 3) the exhaust emission test; and 4) recording of the test data.

The idle inspection and repair flow diagram, Figure 2-10, illustrates the following sequence of events. Based on the exhaust emission test data a pass/fail decision is made and discussed with the vehicle owner. Passed vehicles are certified, and if indicated by the emission data, impending malfunctions are discussed with the vehicle owner. The vehicle is then released. Failed vehicles are diagnosed for probable cause of failure and released to the owner for required repair(s). After the repair(s) are performed, the vehicle is returned to the facility and retested.

The general distinquishing characteristics of the idle mode test are as follows:

- Simple test procedure that requires minimum training for inspectors.
- Carburetor adjustments could be made during test.
- Diagnosis of some engine maladjustments and malfunctions.
- Can be duplicated by either public or private test systems.
- Requires minimal test time and equipment.

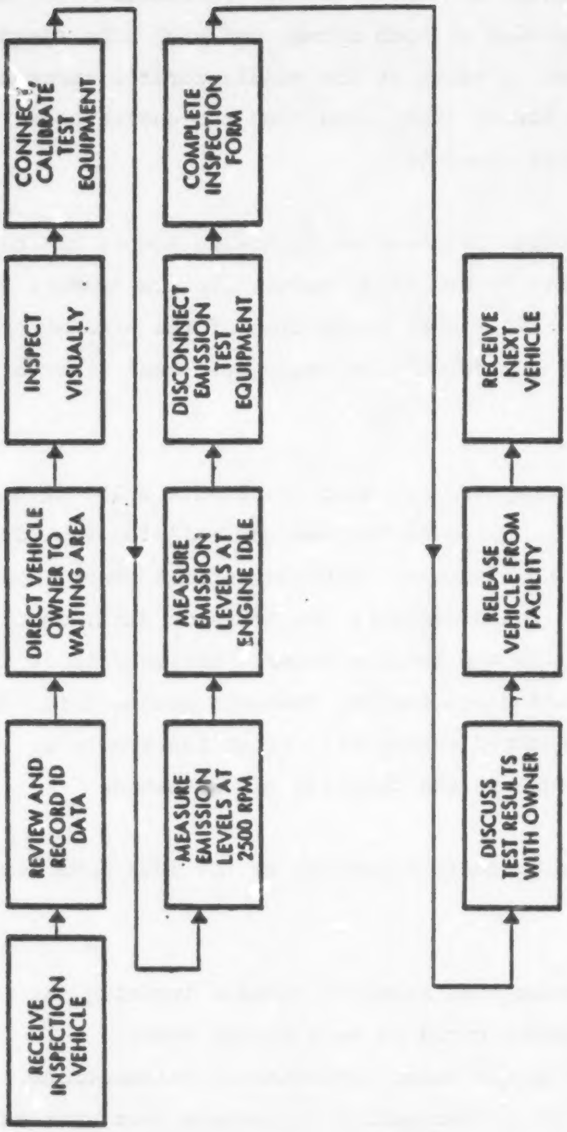

RECEIVE INSPECTION VEHICLE
REVIEW AND RECORD ID DATA
DIRECT VEHICLE OWNER TO WAITING AREA
INSPECT VISUALLY
CONNECT, CALIBRATE TEST EQUIPMENT
MEASURE EMISSION LEVELS AT 2500 RPM
MEASURE EMISSION LEVELS AT ENGINE IDLE
DISCONNECT EMISSION TEST EQUIPMENT
COMPLETE INSPECTION FORM
DISCUSS TEST RESULTS WITH OWNER
RELEASE VEHICLE FROM FACILITY
RECEIVE NEXT VEHICLE

Figure 2-10. IDLE INSPECTION AND REPAIR FUNCTIONS

- Malfunctions that occur under loaded conditions may not be detected.
- NO_x testing cannot be performed.

2.7.2 Output Evaluation for Idle-Mode Test

The output for each testing lane is presented in Table 2-25. These values are based upon 100 percent efficiency and no repeat test.

If one were to assume a 90 percent efficiency and a 30 percent stringency factor, the single position configuration would have an annual output rate of approximately 23,000 under an idle test mode. The lower efficiency is due to queuing problems, rest time, start up and close down times and general personnel problems.

2.8 ADMINISTRATIVE OPTIONS

These administrative options designated by the State of Tennessee are defined as follows:

State-operated - Under this administrative program option, a designated State agency would assume complete managerial and operational control of a system of publicly owned test facilities.

Contractor-operated - A contractor-operated system is an arrangement whereby a single constructor, selected through a competitive bid process, assumes financial and operational responsibility for emission testing. Administrative control is still under the responsibility of a designated State agency.

Private Garage-Operated - In a privately-owned/operated program, a public authority would certify and license qualified establishments (e.g.; service garages, dealerships, and independents) to perform inspections. Managerial and operational authority would be under the direct control of each respective establishment. However, the State would regulate and

Table 2-25. TESTING LANE CONFIGURATIONS

TEST MODE	POSITION 1	POSITION 2	POSITION 3	DAILY OUTPUT[a]	ANNUAL OUTPUT
Idle Mode (plus tampering check for NO_x)					
1	All activities[b]			120	31,200
2	Check-in and test	Check-out		192	49,920
3	Check-in	Test	Check-out	320	83,200

[a] 8-hour day.

[b] Activities are check-in, test, certification.

oversee the program to ensure that I/M requirements and provisions are met. This sytem provides a network of decentralized inspection and repair facilities which would be certified and controlled by the State.

2.8.1 Tax Considerations

Options that require State-owned/operated facilities may generate opposition from municipalities directly affected by I/M. For example, the land acquired for inspection facilities would be purchased by the State. This removes it from municipal tax rolls. This technically is a transfer from the municipality to the State and not a cost or benefit; hence, it becomes a tax revenue loss to the municipality. In contrast, contractor-owned/operated facilities remain under private control, and subject to yearly property taxes with no loss of revenue to the municipality.

2.8.2 Personnel Requirements

A major disadvantage of a State-owned system is a substantial increase in the number of civil service employees. New York has estimated that 4,572 new jobs would be created if it were to adopt a combined safety and exhaust emission inspection. New Jersey's State-owned system currently employs well over 600 persons in its inspection staff alone.

Private garage and contractor-owned/operated systems are free to use part-time employees during periods of high use. This greatly reduces overhead cost. Moreover, private and contractor-operated systems will create new jobs without increasing the State's financial burden.

2.8.3 Program Flexibility

Regarding personnel policies, greater felexibility exists with private garage and contractor-operated systems. If program manpower requirements change, the private sector could respond more readily then the State. Conversely, the State civil service system is considered less flexible.

2.8.4 Funding Interest Rate

For this study, 8 percent interest rate will be used for both State and contractor options.

2.9 ENFORCEMENT

The enforcement mechanism for the I/M program could be tied in with existing motor vehicle registration procedures. The Secretary of State provides for an efficient data-handling system that continuously processes detailed information on owner (name, sex, age, driving history, etc.) and vehicle (make, model, year). This information is constantly updated and is readily available to governmental agencies directly concerned with I/M program requirements. These factors identify the vehicle registration system as a likely candidate as an emission test enforcement control point. The vehicle registration system could provide for an annual inspection process by making an emission test a necessary prerequisite for the successful completion of the registration process. Upon receipt of vehicle registration renewal application, the owner would be required to obtain a Certificate of Compliance from a certified emission test station within a specified period of time. A condition of noncompliance would result if the vehicle owner:

- Ignores emission test requirements
- Fails to pass established emission test standards
- After failure of emission test, does not obtain the necessary repairs and retest within prescribed time schedule.

Noncompliance could result in nonregistration of vehicle and, in effect, deny the right to operate the vehicle.

An optional random spot-check program provides an additional enforcement measure by incorporating vehicle pullover techniques with emission testing. This program may provide statistically adequate samples of the in-use vehicle population in order to gain information on tampering and program effectiveness.

2.10 PUBLIC INFORMATION

The function of a public information program is to familiarize the public and repair establishments with an I/M program. This would include explanations of the purpose and objectives of the program, the program benefits and the operation of the program. Under this latter category, the actual testing procedure should be explained. In addition, information regarding station locations, inspection hours, and consumer protection measures could be made available.

The public information program could take a variety of forms. Advertisements, public service announcements on radio and television, newspaper, and information pamphlets. Section 2.2.5.2 presents estimated cost data relating to:

- Pamphlet preparation and distribution
- Advertisements (e.g., billboards, newspaper, ads, etc.)
- Presentations (e.g., speeches, films, etc.)

In addition, funds needed to finance a comprehensive informational program are allocated on a per vehicle basis.

2.11 BENEFITS DATA

2.11.1 Emissions Standards

The I/M emission standard (cut point or stringency factor) was established by communications from the State of Tennessee at 30 percent.

The Appendix N (FR 24(89): 22177-22183, May 2, 1977; Ref. 40 and Appendix A) sets forth the emission reductions for carbon monoxide (CO) and hydrocarbons (HC).

The methodology used to calculate emissions reductions is as follows:

$$\text{Total Emissions Reductions} = \sum_{i}^{n} \frac{\text{No. Vehicles Each Class} \times \text{Emissions Credits} \times \text{Average Emissions} \times \text{Miles/Year}}{907{,}184 \text{ gr/ton}}$$

where n is class of vehicle, LDV, LDT1, LDT2, HDGV, HDD, MC.

The average emissions as established through Mobile I routine is adjusted for the following features:

- Emission factor data - 49 state
- Vehicle types - LDV, LDT1, LDT2, HDG
- Temperature - 75°F
- Single-speed input - 19.6 mph
- Vehicle miles traveled - 49-state average
- Speed/temperature/operating mode correction factors - 49-state average
- Credit allowance from Appendix N
  -air conditioning - 49-state average
  -extra loading - 49-state average
  -trailer loading - 49-state average
  -humidity - 49-state average
- Vehicle age distribution - 49-state average

2.11.2 Fuel Savings Data and Methodology

The amount of fuel saved by instituting mandatory vehicle procedures is a function of many variables. The following parameters are of particular importance: vehicle type, number of miles traveled per year, fuel efficiency (miles per gallon), stringency factor, fuel consumption, etc. These variables are related in the following manner:

$$G_s = \left[(V_m/F_e) \times F_c \; (T_v \times S_f) \right]$$

where:

G_s = Fuel gallons saved

V_m = Mileage per vehicle traveled per year

F_e = Fuel efficiency

F_c = Increased fuel consumption per failed vehicle = 3.8 percent, as established from FTP tests by the State of California Mandatory I/M Program

T_v = Total vehicle population

S_f = Stringency factor = 0.30

Once the total fuel requirements are known, the estimated fuel savings are calculated:

$$F_s = (G_s) \times (G_p)$$

F_s = Fuel savings (dollars)

G_s = Gallons saved

G_p = Estimated price per gallon ($0.75/gal)

Differences in the above variables will directly influence fuel savings. Therefore, the following assumptions for LDVs are noted:

- 11,500 miles traveled per year (V_m)
- Estimated 15 miles per gallon (F_e)
- Projected growth rate as presented in Section 2.6.

Section 3

COST ANALYSIS - OPTION 1

The scenario for Option 1 is as follows:

- State-administered
- Idle-mode
- Nonattainment area: 4 counties
- Inspection of LDV and LDT only
- Vehicle registration as the enforcement mechanism
- Thirty percent stringency factor
- Double-lane single-position stations

3.1 OPTION DEFINITION

This option is a State-administered network of State-operated test stations in the nonattainment counties. The nonattainment counties are presented in Figure 2-9, Section 2.5. The configuration of the test stations are presented in Section 2.7.2, and personnel complement is presented in Section 2.3. This option inspects light-duty vehicles and light-duty trucks. The test station is designed for double-lane, single-position lanes.

The assumed stringency factor throughout this analysis is 30 percent. This means that the program is designed to fail 30 percent of the vehicles tested. Assuming that all failed vehicles would have to be retested before registration, the actual number of inspections to be performed is 30 percent higher than the vehicle population required to participate in the program.

Preceding page blank

The throughput time used in establishing the capacity of the testing stations was 3.75 minutes as noted in Section 2.

The assumptions made are:

- Initially, the work schedule is 40 hours per week, 52 weeks per year, for a total of 2,080 hours. Vacation time, sick leave, etc., manpower requirements of 120 hours per person per year would be taken care of by an extended work week of 2 to 4 hours per week. In later years, work schedule would be extended to meet demand of increasing vehicle population.

- An efficiency factor of 0.90 was used as noted in Section 2. It is presumed that the efficiency of these stations would be improved through improved queuing techniques and continued learning improvements from a low of 0.67 (identified as the low value in efficiency factor in other programs) to the 0.90 efficieny factor assumed in this analysis. To increase cost to a lower efficiency, direct labor and test station capital cost figures would have to be adjusted to the ratio of 0.90/x where x is the lower efficiency.

- To minimize service problems, parking problems, land acquisition problems, a maximum of two lanes was used as the preferred configuration except in the rural areas. Tables 2-19 through 2-23 present sensitivity factors for cost items as related to test station configuration for one to six lanes. Table 2-25, provides throughput sensitivity factors for station configurations with one-to three-position lanes.

3.2 FACILITIES REQUIREMENTS

Facility Capacity - Facility capacity was determined by analyzing vehicle population and output rate data. Table 3-1 presents test lane and facility requirements for the designated four counties. The projected test facilities

Table 3-1. TEST LANE AND FACILITY REQUIREMENTS
Year - 1982

COUNTY	# OF VEHICLES (1982)	# OF LANES REQUIRED[a]	DOUBLE-LANE FACILITY
Chattanoga (Hamilton)	132,197	6	3
Memphis (Shelby)	388,259	17	9
Nashville (Davidson)	270,270	12	6
Knoxville (Knox)	134,700	6	3
TOTAL	925,426	42	21

[a] Output rate of a single-lane, one position station is 29,952 vehicles/year, assuming 90% working efficiency. The stringency factor is assumed to be 30%.

would be able to provide services for six years of I/M programs with extended work schedule.

Quality Control Facilities and Equipments - One referee lane will be built to handle consumer complaints. Each county would have one mobile vehicle for regular quality control purpose and first-line consumer complaints. Thus, a total of four mobile vehicles is required.

3.3 OPTION COSTS

The costs associated with an I/M program implementation and operation are:

- Construction
- Operating costs
- Consumer protection costs
- Initial implementation costs
- Other capital costs

Reference should be made to the discussion in Section 2 concerning base data and analytical techniques relating to the development of these costs.

In order to determine the costs, additional assumptions were made. These assumptions are:

- All capital costs would have to be made available in the year 1981 to assure implementation of program in 1982. However, these costs would be recorded in the year 1982 and allowed for six years of amortization.

- The additional requirements for vehicle population growth would be compensated over the 6-year period of operation of the I/M program.

- Operation costs would reflect the requirement for extended work week to compensate for vehicle population growth.

Capital (One Time Costs) - The construction costs, other capital costs, and implementation costs for Option 1 reflecting three configurations (the manual system, the semi-automatic system, and the automated system) are presented in Tables 3-2, 3-3, and 3-4, respectively.

On-Going Costs - The operating costs and consumer protection costs are presented in Table 3-5, and 3-6, respectively for the years 1982 through 1987.

The total costs for Option 1 over a 6-year period without regard to cost of money (1978 dollars) are presented as follows:

Test System	Total Costs (1978 Million Dollars)
Manual	$19.8
Semi-automated	$20.2
Automated	$20.6

It should be noted that costs as generated above reflect only direct costs, except for supplies, personnel training, personnel benefits, and minor support service.

3.4 CONSUMER FEE

In order to calculate consumer fee charge, program costs should be converted into annualized costs. The annualized cost amortizes capital expenditure over 6 years of I/M program operation. Assuming cost of capital to be 6 percent, annualized costs of this option are presented in Table 3-7. In the table, general and administrative costs were included by assuming 73 percent over total program costs (see Part III, Section 1.3 for details). The average annualized cost would be close to $6 million per year.

Table 3-2.
CONSTRUCTION COSTS[a]
OPTION: STATE-OPERATED, IDLE TEST
YEAR - 1982
(1978 DOLLARS)

COST CONSIDERATION	MANUAL	SEMI-AUTOMATED	AUTOMATED
1. Land & Off-site Improvement	2,177,200	2,177,200	2,177,200
2. Facility Construction	1,105,600	1,105,600	1,105,600
3. Instrumentation	169,100	169,100	169,100
4. Office Equipment	42,000	42,000	42,000
5. Computer Costs			
a. hardware	0	273,000	734,000
b. software	100,000	108,000	108,000
TOTAL	3,593,900	3,874,900	4,335,900

[a] Existing facilities in Hamilton and Shelby counties were not considered in the cost analysis.

Table 3-3.
OTHER CAPITAL COSTS
OPTION: STATE-OPERATED, IDLE TEST
YEAR - 1982
(1978 DOLLARS)

COST CONSIDERATION	MANUAL	SEMI-AUTOMATED	AUTOMATED
1. Administrative Office Equipment	12,000	12,000	12,000
2. Quality Control			
a. mobile unit (4)	79,800	79,800	79,800
b. referee station[a] (1)	227,600	227,600	227,600
c. correlation car	10,200	10,200	10,200
3. Consumer Complaint (3 complaint inspection cars)	15,000	15,000	15,000
4. Vehicle Test Scheduling (software development)	67,000	67,000	67,000
5. Mechanic Training	200	200	200
TOTAL	411,800	411,800	411,800

[a] Costs include land and facility construction costs.

Table 3-4.
INITIAL IMPLEMENTATION COSTS
OPTION: STATE-OPERATED, IDLE TEST
YEAR - 1982
(1978 DOLLARS)

COST CONSIDERATION	MANUAL	SEMI-AUTOMATED	AUTOMATED
1. Site Selection	13,400	13,400	13,400
2. Bid Preparation and Evaluation	9,300	9,300	14,800
3. Design of Facilities	179,800	193,800	216,800
4. Training Plan Development	3,500	3,500	3,500
5. Personnel Selection	35,800	35,800	35,800
6. Document Preparation	7,800	7,800	7,800
7. Administrative Support	10,000	10,000	10,000
8. System Certification	900	900	900
9. System Integration and Checkout	12,600	12,600	21,000
TOTAL	273,100	287,100	324,000

Table 3-5.
OPERATING COSTS
OPTION: STATE-OPERATED, IDLE TEST
(1978 DOLLARS)

COST ITEMS	1982	1983	1984	1985	1986	1987	TOTAL
1. Facility Operation							
a. Personnel	1,326,600	1,361,600	1,396,600	1,431,700	1,466,700	1,501,700	8,484,900
b. Maintenance, supplies and utility costs	109,200	109,200	109,200	109,200	109,200	109,200	655,200
c. Equipment Maintenance[a]	10,500	10,500	10,500	10,500	10,500	10,500	63,000
2. Quality Control Costs							
a. Personnel	120,400	120,400	120,400	120,400	120,400	120,400	722,400
b. Supply	1,200	1,200	1,200	1,200	1,200	1,200	7,200
c. Maintenance of mobile unit, referee stations, and correlation vehicle	19,600	19,600	19,600	19,600	19,600	19,600	117,600
3. Support							
a. Administration	211,600	211,600	211,600	211,600	211,600	211,600	1,269,600
b. Data Analyses	45,000	45,000	45,000	45,000	45,000	45,000	270,000
c. Training	21,000	21,000	21,000	21,000	21,000	21,000	126,000
TOTAL	1,865,100	1,900,100	1,935,100	1,970,200	2,005,200	2,040,200	11,715,900

[a] For semi-automated system, equipment maintenance cost would be $38,900; it would be $85,000 for automated system.

Table 3-6.
CONSUMER PROTECTION COSTS[a]
OPTION: STATE-OPERATED, IDLE STATION
(1978 DOLLARS)

COST ITEMS	1982	1983	1984	1985	1986	1987	TOTAL
1. Mechanic Training	b	b	b	b	b	b	b
2. Public Information	231,300	236,400	241,500	246,600	251,700	262,000	1,469,500
3. Consumer Complaint	89,700	89,700	89,700	89,700	89,700	89,700	538,200
4. Vehicle Test Schedule[c]	291,000	297,400	303,300	309,300	315,200	327,100	1,843,300
TOTAL	612,000	623,500	634,500	645,600	656,600	678,800	3,851,000

[a] Costs are the same for semi-automated and automated systems.

[b] Self-supporting operation.

[c] Based upon nonintegration with vehicle registration. If integrated with registration it would be negligible.

Table 3-7.
ANNUALIZED COSTS OF I/M PROGRAM - OPTION 1, MANUAL TEST SYSTEM[a]
(1978 DOLLARS)

CATEGORY	TOTAL AMORTIZED COST	AVERAGE ANNUALIZED COST ($/Year)
I. Construction costs	3,593,900 x 0.20336 x 6 = 4,385,100	4,385,100/6 = 730,900
II. Other capital costs	411,800 x 0.20336 x 6 = 502,500	502,500/6 = 83,800
III. Initial implementation costs	273,100 x 0.20336 x 6 = 333,200	333,200/6 = 55,500
IV. Operating costs		11,715,900/6 = 1,952,700
V. Consumer protection costs		3,851,000/6 = 641,800
Subtotal		3,464,700
VI. General administration and overhead (@ 73%)		2,529,200
TOTAL		5,993,900

[a] All costs are rounded-off to hundred dollars.

[b] See Section 1.3 for assumptions.

The consumer fee is calculated as follows:

AVERAGE ANNUALIZED COST	AVERAGE VEHICLE POPULATION	CONSUMER FEE
$3,464,700	x $\frac{1}{986,600}$	= $3.51 (Without State G/A and Overhead)
$5,993,900	x $\frac{1}{986,600}$	= $6.08 (With Assumed G/A and Overhead of 73 percent)

Thus, the average consumer fee would be in the range of $3.51 to $6.08 (in 1978 dollars). This fee would apply to manual inspection system only. The fee would be approximately 2 percent and 4 percent higher for semi-automated and automated systems, respectively.

Section 4

COST ANALYSIS - OPTION 2

This section is a cost analysis of Option 2 which is a contractor administered network of test station with the State of Tennessee administering all other functions as performed under Option 1. The area covered is the non-attainment counties as set forth in Figure 2-9, Section 2.5.

The scenario for Option 2 is as follows:

- o Contractor administration of testing stations
- o Idle-mode
- o Nonattainment area coverage = 4 counties
- o Inspection of LDV only
- o Double-lane, single-position stations
- o Vehicle registration as the enforcement mechanism
- o Thirty percent stringency factor

4.1 COST ANALYSIS

The additional assumptions other than those under Option 1 are:

- o The contractor costs in the base table are only those costs associated with test facility operation.
- o The contractor costs for total costs development and fee calculations are increased to allow for the following factors:
  - 0.50 factor for overhead costs to administer the test stations

- 0.15 general and administration costs
- 0.10 profit factor
- Total factor is 1.50 x 1.50 x 1.15 x 1.10 = 1.90

- The State costs for total cost development and fee calculations are increased to allow for the following factors:
  - 0.50 factor for those overhead supporting costs not included in the detail costs of the analysis tables. To arrive at a finite detail cost analysis, a complete documentation of the State of Tennessee's accounting practice would be required.
  - 0.15 general and administrative costs are those costs of the executive and legislative that would be related to the I/M program.
  - Total cost factor is 1.50 x 1.15 = 1.73

- Station complement is the same as for Option 1. There is no change in efficiency between State- or contractor-operated facilities.

The unit costs associated with Option 2 and facility are the same as in Option 1. Facilities repair reference should be made to the discussion in Section 2 concerning base data factors and analytical techniques relating to the development of these costs.

Capital Costs (One-Time Costs) - The construction, the other capital costs and implementation costs for Option 2 reflecting three configurations; the manual system, the semi-automated system and the automated system are presented in Tables 4-1, 4-2, and 4-3, respectively.

Ongoing Costs - The operation costs and consumer protection costs are presented in Tables 4-4, and 4-5, respectively for the years 1982 through and including 1987.

Table 4-1.
CONSTRUCTION COSTS[a]
OPTION: CONTRACTOR-OPERATED, IDLE TEST
YEAR - 1982
(1978 DOLLARS)

COST CONSIDERATION	MANUAL	SEMI-AUTOMATED	AUTOMATED
1. Land & Off-site Improvement[b]	2,177,200	2,177,200	2,177,200
2. Facility Construction[b]	1,105,600	1,105,600	1,105,600
3. Instrumentation[b]	169,100	169,100	169,100
4. Office Equipment[b]	42,000	42,000	42,000
5. Computer Costs			
a. hardware[b]	0	273,000	734,000
b. software			
state	100,000	100,000	80,000
contractor	0	8,000	28,000
TOTAL	3,593,900	3,874,900	4,335,900

[a] Existing facilities in Hamitlon and Shelby counties were not considered in the cost analysis.

[b] Cost to the contractor.

Table 4-2.
OTHER CAPITAL COSTS[a]
OPTION: CONTRACTOR-OPERATED, IDLE TEST
YEAR - 1982
(1978 DOLLARS)

COST CONSIDERATION	MANUAL	SEMI-AUTOMATED	AUTOMATED
1. Administrative Office Equipment	12,000	12,000	12,000
2. Quality Control			
a. mobile unit (4)	79,800	79,800	79,800
b. referee station[b] (1)	227,600	227,600	227,600
c. correlation car	10,200	10,200	10,200
3. Consumer Complaint (3 complaint inspection cars)	15,000	15,000	15,000
4. Vehicle Test Scheduling (software development)	67,000	67,000	67,000
5. Mechanic Training	200	200	200
TOTAL	411,800	411,800	411,800

[a] Costs to the State.

[b] Costs include land and facility construction costs.

Table 4-3.
INITIAL IMPLEMENTATION COSTS
OPTION: CONTRACTOR-OPERATED, IDLE TEST
YEAR - 1982
(1978 DOLLARS)

COST CONSIDERATION	MANUAL	SEMI-AUTOMATED	AUTOMATED
1. Site Selection[a]	13,400	13,400	13,400
2. Bid Preparation and Evaluation[a]	9,300	9,300	14,800
3. Design of Facilities[b]	179,800	193,800	216,800
4. Training Plan Development[a]	3,500	3,500	3,500
5. Personnel Selection[b]	35,800	35,800	35,800
6. Document Preparation[a]	7,800	7,800	7,800
7. Administrative Support[a]	10,000	10,000	10,000
8. System Certification[a]	900	900	900
9. System Integration and Checkout[b]	12,600	12,600	21,000
TOTAL	273,100	287,100	324,000

[a] Cost to the State.

[b] Cost to the contractor.

Table 4-4.
OPERATING COSTS
OPTION: CONTRACTOR-OPERATED, IDLE TEST
(1978 DOLLARS)

COST ITEMS	1982	1983	1984	1985	1986	1987	TOTAL
1. Facility Operation							
a. Personnel[a]	1,326,600	1,361,600	1,396,600	1,431,700	1,466,700	1,501,700	8,484,900
b. Maintenance, supplies and utility costs[a]	161,700	161,700	161,700	161,700	161,700	161,700	970,200
c. Equipment Maintenance[a,b]	10,500	10,500	10,500	10,500	10,500	10,500	63,000
2. Quality Control Costs							
a. Personnel[c]	120,400	120,400	120,400	120,400	120,400	120,400	722,400
b. Supply[c]	1,200	1,200	1,200	1,200	1,200	1,200	7,200
c. Maintenance of mobile unit, referee stations, and correlation vehicle[c]	19,600	19,600	19,600	19,600	19,600	19,600	117,600
3. Support							
a. Administration[c]	211,600	211,600	211,600	211,600	211,600	211,600	1,269,600
b. Data Analyses[c]	45,000	45,000	45,000	45,000	45,000	45,000	270,000
c. Training							
o State	3,700	3,700	3,700	3,700	3,700	3,700	22,200
o Contractor	17,300	17,300	17,300	17,300	17,300	17,300	103,800
State Total	401,500	401,500	401,500	401,500	401,500	401,500	2,409,000
Contractor Total	1,516,100	1,551,100	1,586,100	1,621,200	1,656,200	1,691,200	9,621,900
TOTAL	1,917,600	1,952,600	1,987,600	2,022,700	2,057,700	2,092,700	12,030,900

[a] Cost to the contractor.

[b] For semi-automated system, equipment maintenance cost would be $38,900; it would be $85,000 for automated system.

[c] Cost to the State.

Table 4-5.
CONSUMER PROTECTION COSTS[a,b]
OPTION: CONTRACTOR-OPERATED, IDLE STATION
(1978 DOLLARS)

COST ITEMS	1982	1983	1984	1985	1986	1987	TOTAL
1. Mechanic Training	c	c	c	c	c	c	c
2. Public Information	231,300	236,400	241,500	246,600	251,700	262,000	1,469,500
3. Consumer Complaint	89,700	89,700	89,700	89,700	89,700	89,700	538,200
4. Vehicle Test Schedule[d]	291,000	297,400	303,300	309,300	315,200	327,100	1,843,300
TOTAL	612,000	623,500	634,500	645,600	656,600	678,800	3,851,000

[a] Costs are the same for semi-automated and automated systems.

[b] Cost to the State.

[c] Self-supporting operation.

[d] Based upon nonintegration with vehicle registration. If integrated with registration it would be negligible.

The total costs for Option 2 over the 6-year period without regard to cost of money are presented as follows:

TOTAL COSTS
(1978 Million Dollars)

TEST SYSTEM	STATE	CONTRACTOR	TOTAL
Manual	$6.82	$13.34	$20.16
Semi-Automated	$6.82	$13.66	$20.48
Automated	$6.80	$14.23	$21.03

These costs only reflect direct costs, except for supplies, personnel training, personnel benefits, and minor support service.

Average Annualized Cost

The average annualized cost for Option 2 over the 6-year operation is presented in Table 4-6. The state would share $2 million per year. For the contractor, annualized cost would be $4.49 million per year.

Table 4-6. ANNUALIZED COSTS OF I/M PROGRAM - OPTION 2 (1978 Dollars)[a]

COST CATEGORY	TOTAL AMORTIZED COST	AVERAGE ANNUALIZED COST (/YEAR)
I. Construction Costs		
-state	100,000 x .20336 x 6 = 122,000	122,000/6 = 20,300
-contractor	3,493,900 x 0.20336 x 6 = 4,263,100	4,263,100/6 = 710,500
II. Other Capital Costs		
-state	411,800 x 0.20336 x 6 = 502,500	502,500/6 = 83,800
-contractor	0	0
III. Initial Implementation Costs		
-state	44,900 x 0.20336 x 6 = 54,800	54,800/6 = 9,100
-contractor	228,200 x 0.20336 x 6 = 278,400	278,400/6 = 46,400
IV. Facility Operating Costs		
-state		(1,269,600 + 270,000 + 22,200 + 722,400 + 7,200 + 117,600)/6 = 401,500
-contractor		(848,900 + 970,200 + 63,000 + 103,800)/6 = 1,603,700
V. Consumer Protection Costs		
-state		3,851,000/6 = 641,800
-contractor		0
SUBTOTAL		
-state		1,156,500
-contractor		2,360,600
VI. General Administration, Overhead and Profit		
-state (@ 73%)		844,300
-contractor (@90%)[b]		2,124,500
TOTAL		
-state		2,000,800
-contractor		4,485,100

[a] All costs are rounded off to hundred dollars. Costs are related to manual system only.

[b] See Section 1.1 for assumptions.

4.2 CONSUMER FEE

The consumer fee is calculated as follows:

FEE SHARE	AVERAGE ANNUALIZED COST	AVERAGE VEHICLE POPULATION	CONSUMER FEE
State	1,156,500	x $\frac{1}{986,600}$	= $1.17 (Without G/A and overhead)
Contractor	2,360,600	x $\frac{1}{986,600}$	= $2.39 (Without G/A and overhead)
TOTAL			$3.56
State	2,000,800	x $\frac{1}{986,600}$	= $2.03 (With assumed G/A & overhead of 73 percent)
Contractor	4,485,100	x $\frac{1}{986,600}$	= $4.55 (With assumed G/A & overhead of 90 percent)
TOTAL			$6.58

Thus, the consumer fee is in the range of $3.56 to $6.58. The state would share $1.17 to $2.03, while the contractor would share $2.39 to $4.55.

Section 5

COST ANALYSIS - OPTION 3

This section presents cost analysis for Option 3. This option defines an I/M program as a private garage-operated network using idle test.

Scenario of this I/M option is summarized as follows:

- Private garage-operated inspection network
- Idle-mode test
- Nonattainment area coverage - 4 counties
- Inspection of LDV only
- Vehicle registration as the enforcement mechanism
- Thirty percent stringency factor

This option has the following specific assumptions:

- All private garages would participate
- Only manual inspection equipment will be installed

5.1 COST ANALYSIS

For convenience, costs were grouped into four categories as opposed to the state- and contractor-operated options. This option does not have costs of constructing new facilities. Rather, private garages that are willing to participate in the I/M program will purchase the necessary testing equipment. Under this option, the State would assume capital costs of administrative office equipment, quality control equipment, mechanic training, consumer complaint, and vehicle test scheduling.

Private garage distributions within the four counties are presented in Table 5-1.

Table 5-1. NUMBER OF PRIVATE GARAGES

COUNTY	NUMBER
Davidson	160
Hamilton	88
Knox	88
Shelby	242
TOTAL	578

Source: State of Tennessee, Planning Department

Since each mobile vehicle is able to certifying four stations per day, each county would require one mobile van to maintain a 90-day regular quality control checkup. One referee station is also required for this option to handle consumer complaints.

Tables 5-2 and 5-3 present capital and initial implementation costs of this option. In costing instrumentation, it was assumed that all private garages would participate in the I/M program.

Table 5-2. CAPITAL COSTS
OPTION: PRIVATE GARAGE-OPERATED, IDLE-MODE, YEAR - 1982
(1978 Dollars)

COST ITEMS	TOTAL
1. Instrumentation[a]	2,312,000[b]
2. Administrative Office equipment[c]	12,000
3. Quality control equipment[c]	
a. Mobile unit (4)	79,800
b. Referee station (1)	227,600
c. Correlation car	10,200
4. Mechanic Training[c]	200
5. Consumer complaint[c]	15,000
6. Vehicle Test Scheduling[c] (Software development)	67,000
TOTAL	2,723,800

[a] Cost to private garage based on 578 private garages in 4 counties.

[b] $4,000 per private garage.

[c] State cost.

Table 5-3. INITIAL IMPLEMENTATION COSTS
OPTION: PRIVATE GARAGE-OPERATED, IDLE-TEST, YEAR - 1982
(1978 Dollars)

COST CONSIDERATION	TOTAL
1. Site selection[a]	0
2. Bid Preparation and evaluation[a]	0
3. Design of facilities[a]	0
4. Training plan development[a]	3,500
5. Personnel selection[a]	35,800
6. Document preparation[a]	7,800
7. Administrative support[a]	10,000
8. System certification[a]	13,000[b]
9. System integration and checkout[c]	173,400
TOTAL	243,500

[a] Costs to the State.

[b] Minimum cost based upon a 5 percent sampling plan.

[c] Cost to the private garage.

Operating costs are presented in Table 5-4. Cost of facility operation is expected to increase with more vehicles to be inspected in later years. However, support and quality control costs are approximately constant over the 6-year operation. The State would assume an operating cost of $2.41 million per year; private garages would have an average operating cost of $6.25 million per year.

Consumer protection cost for this option was estimated to be the same as Option 1 (Table 5-5).

5.2 CONSUMER FEE

Average annualized cost is determined by amortizing capital costs over 6 years. Results are presented in Table 5-6.

Table 5-4. OPERATING COSTS
OPTION: PRIVATE GARAGE-OPERATED, IDLE TEST
(1978 Dollars)

COST ITEMS	1982	1983	1984	1985	1986	1987	TOTAL
1. Facility operation[a]	977,500	1,003,300	1,029,100	1,054,900	1,080,700	1,106,500	6,252,000
2. Support[b]							
a. Administration	211,600	211,600	211,600	211,600	211,600	211,600	1,269,600
b. Data Analyses	45,000	45,000	45,000	45,000	45,000	45,000	270,000
c. Training	3,700	3,700	3,700	3,700	3,700	3,700	22,200
3. Quality control costs[b]							
a. Personnel	120,400	120,400	120,400	120,400	120,400	120,400	722,400
b. Supply	1,200	1,200	1,200	1,200	1,200	1,200	7,200
c. Maintenance of mobile unit, referee stations, and correlation vehicle	19,600	19,600	19,600	19,600	19,600	19,600	117,600
TOTAL	1,379,000	1,404,800	1,430,600	1,456,400	1,482,200	1,508,000	8,661,000

[a] Costs to the private garage.

[b] Costs to the State.

Table 5-5. CONSUMER PROTECTION COSTS[a]
OPTION: PRIVATE GARAGE-OPERATED, IDLE STATION
(1978 Dollars)

COST ITEMS	1982	1983	1984	1985	1986	1987	TOTAL
1. Mechanic Training	b	b	b	b	b	b	b
2. Public Information	231,300	236,400	241,500	246,600	251,700	262,000	1,469,500
3. Consumer Complaint	89,700	89,700	89,700	89,700	89,700	89,700	538,200
4. Vehicle Test Schedule[c]	291,000	297,400	303,300	309,300	315,200	327,100	1,843,300
TOTAL	612,000	623,500	634,500	645,600	656,600	678,800	3,851,000

[a] Costs are the same for semi-automated and automated systems.

[b] Self-supporting operation.

[c] Based upon nonintegration with vehicle registration. If integrated with registration it would be negligible.

Table 5-6. ANNUALIZED COSTS OF I/M PROGRAM - OPTION 3 (1978 Dollars)[a]

COST CATEGORY		TOTAL AMORTIZED COST	AVERAGE ANNUALIZED COST (/YR)
I.	State	411,800 x 0.20,336 x 6 = 502,500	502,500/6 = 83,800
	Private Garage	2,312,000 x 0.20336 x 6 = 2,821,000	2,821,000/6 = 470,200
II.	Initial Implementation Costs		
	State	(3,500 + 35,800 + 7,800 + 10,000 + 13,000) x 0.20336 x 6 = 85,500	85,500/6 = 14,300
	Private Garage	173,400 x 0.20336 x 6 = 211,600	211,600/6 = 35,200
III.	Private Garage Operating Costs		
	State		(1,269,600 + 270,000 + 22,200 + 722,400 + 7,200 + 117,600)/6 = 401,500
	Private Garage		6,252,000/6 = 1,042,000
IV.	Consumer Protection Costs		
	State		3,851,000/6 = 641,800
	Private Garage		0
	SUBTOTAL		
	State		1,141,400
	Private Garage		1,547,400
V.	General Administration, Overhead and Profit		
	State (@ 73 percent)		833,200
	TOTAL		
	State		1,974,600
	Private Garage		1,547,400

[a] All costs are rounded off to hundred dollars

[b] See Section 1.1 for assumptions.

By using the same method as Option 1 and Option 2, consumer fee for this option is as follows:

FEE SHARE	FEE (1978 Dollars) Without State G/A And Overhead	With Assumed State G/A And Overhead
State	1.15	2.00
Private Garage	1.57	1.57[a]
TOTAL	2.72	3.57

[a] No additional overhead assumes for the private garage, however, it is noted that this cost could vary in accordance with the throughput efficiency of the private garage. This also does not consider any other charges by the private garage. For servicing the vehicle such as carburetor and timing adjustments or other repairs.

Section 6

COST ANALYSIS - OPTION 4

This section presents cost analysis for Option 4. This option defines an I/M program with state and local county joint adminstration. This inspection network can be either centralized (state/local county-operated, or contractor-operated) or decentralized (private-garage operated).

Scenario of this I/M option is summarized as follows:

- Idle-mode test.
- Nonattainment areas - 4 counties.
- State/local county joint administration.
- Inspection network can be state/local county-operated, or contractor-operated, or private-garage operated.
- Inspection of LDVs and LDTs only.
- Vehicle registration as the enforcement mechanism.
- Thirty percent stringency factor.
- Double-lane single position station will be built of centralized inspection system is adopted.

Preceding page blank

Specific assumptions for this option are as follows:

- Local counties will assume the construction and operating costs of testing facilities, if they adopted centralized inspection system.
- The State will administer the quality control of an I/M program, but local counties will monitor and inspect testing facilities.
- All state costs, such as personnel, support, etc., will be proportionally distributed to local counties by vehicle population within counties.
- Four counties will participate in the I/M program.

6.1 FACILITIES REQUIREMENTS

In a centralized inspection system test facility capacity requirements for this option are the same as those for Option 1 (see Table 3-1). Since local counties are responsible for the construction and operation of testing facilities, only manual-type inspection system is considered as being feasible. As for a decentralized inspection system, private-garages will provide the inspection services.

Under this option, each county would acquire and maintain a mobile vehicle for quality control purpose. There will be no referee station; instead, mobile vehicle will provide testing services related to consumer complaints.

6.2 PERSONNEL REQUIREMENTS

Operations personnel requirements for the centralized system under this option are presented in Table 6-1.

Table 6-1. I/M PROGRAM OPERATIONS PERSONNEL REQUIREMENTS
OPTION 4 - CENTRALIZED SYSTEM

COUNTY	TEST FACILITY PERSONNEL[a]	QUALITY CONTROL OPERATIONS PERSONNEL[b]
Davidson	36	2
Hamilton	18	2
Knox	18	2
Shelby	54	2
Total	126	8

[a] See Section 2.3.1 for unit requirements. The requirements apply to centralized (state/county for contractor-operated) system only.

[b] See Section 2.3.3 for unit requirements. There will be no referee lane personnel requirements for this option.

The requirements are the same as Option 1. However, there will be no referee lane personnel requirements.

The option by its nature will require two levels of administrative personnel requirements - state and county levels. Table 6-2 lists the administrative personnel requirements. Each county will reqire an assistant field administrator to be in charge of its I/M operation. The environmental engineer will be responsible for local quality control operations and consumer complaints.

6.3 COST ANALYSIS

The option has both state and local county jointly administer the program. State cost would have to be shared by counties participating in the program. The methodology to determine the shares is to distribute state costs by the ratio of county vehicle population with respect to the total vehicle population.

Detailed cost items as outlined in Section 2.2 were analyzed for the four counties. The analysis considered three possible operation alternatives - county operation, contractor operation, and private-garage operation. Table 6-3 summarizes costs for each county with each possible operation alternative. Detailed results are presented in Appendix H.

Table 6-2. ADMINISTRATIVE PERSONNEL REQUIREMENT AND YEARLY COSTS OPTION 4

PERSONNEL CATEGORY	NUMBER REQUIRED	SALARY + 17% BENEFIT FACTOR	TOTAL
I. **State Level**			
I/M Program Administrator	1	$20,150	$ 20,150
Secretary (Clerk Typist III)	1	8,790	8,790
Clerk I	2	7,300	14,600
Environmental Engineer	1	12,770	12,700
Statistical Analyst	1	12,770	12,770
Assistant Program Administrator (Quality Control)	1	16,380	16,380
Environmental Engineer	1	12,770	12,770
Clerk - Typist I	2	7,300	14,600
Statistical Analyst	1	12,770	12,770
Total			$125,600
II. **County Level**[a]			
Assistant Program Administrator (Testing)	1	$16,380	$ 16,380
Clerk - Typist I	2	7,300	14,600
Environmental Engineer	1	12,770	12,770
Total			$ 43,750

[a] Required in each county.

Table 6-3. TOTAL COSTS FOR I/M PROGRAMS FOR COUNTY ADMINISTERED OPTION OPERATING FROM 1982 THROUGH 1987 - MANUAL SYSTEM ONLY (IN THOUSANDS OF 1978 DOLLARS)

COST ITEM	DAVIDSON COUNTY			HAMILTON COUNTY			KNOX COUNTY			SHELBY COUNTY		
	County	Contractor	Private Garage	County[a]	Contractor[a]	Private Garage	County	Contractor	Private Garage	County[a]	Contractor[a]	Private Garage
Contruction												
state[b]	29	29	0	14	14	0	15	15	0	42	42	0
county	998.3	0	0	499.1	0	0	499.1	0	0	1,497.4	0	0
contractor	-	998.3	-	-	499.1	-	-	499.1	-	-	1,497.4	-
private garage[c]	-	-	640	-	-	352	-	-	352	-	-	968
Other Capital												
state[b]	22.3	22.3	22.3	10.8	10.8	10.8	11.1	11.1	11.1	31.9	31.9	31.9
county	38.4	38.4	38.4	38.4	38.4	38.4	38.4	38.4	38.4	38.4	38.4	38.4
Initial Implementation												
state	0	0	0	0	0	0	0	0	0	0	0	0
county	102.5	38.5	35.3	74.6	37.3	26.4	74.6	37.3	26.4	135.1	39.7	72.6
contractor	-	64	-	-	37.3	-	-	37.3	-	-	95.4	-
private garage	-	-	48	-	-	33.8	-	-	33.8	-	-	41.8
Operation Costs												
state[b]	329.4	329.4	329.4	168	168	168	170.4	170.4	170.4	468	468	468
county	3,063	433.8	433.8	1,748.4	433.8	433.8	1,748.4	433.8	433.8	4,377.6	433.8	433.8
contractor	-	2,719.2	-	-	1,359.6	-	-	1,359.6	-	-	4,078.8	-
private garage	-	-	1,826.1	-	-	892.9	-	-	910.2	-	-	2,623
Consumer Protection												
state	939	939	939	456.4	456.4	456.4	469.6	469.6	469.6	1,350.4	1,350.4	1,350.4
county	157.2	157.2	157.2	76.2	76.2	76.2	78.6	78.6	78.6	226.2	226.2	226.2
contractor	-	0	-	-	0	-	-	0	-	-	0	-
private garage	-	-	0	-	-	0	-	-	0	-	-	0
TOTAL	5,679.1	5,769.1	4,469.5	3,085.9	3,130.9	2,488.7	3,105.2	3,150.2	2,524.3	8,167	8,302	6,254.1

[a] Existing facilities not considered in costing of this program.

[b] State costs were appropriated to local counties, assuming four-county participation. Costs of construction ($100,000), other capital ($76,100), and operation ($1,135,800) for the state are fixed costs. These state costs would have to be redistributed, if fewer counties participate.

[c] Instrumentation cost only. No facility construction needed.

Caution should be made here that the program cost of each county would change if fewer counties participate in the I/M program. In fact, fixed costs for the State would have to be redistributed; therefore, program cost for each county would expect to be higher with fewer counties getting involved.

6.4 CONSUMER FEE

By using the same method as Option 1, consumer fees under Option 4 are presented in Table 6-4.

Table 6-4. CONSUMER FEE - OPTION 4
(IN 1978 DOLLARS)

	COUNTY			
OPERATION ALTERNATIVE	Davidson	Hamilton	Knox	Shelby
County	5.94	6.60	6.52	5.96
Contractor	6.43	7.10	7.00	6.46
Private-Garage	3.52	4.12	4.10	3.40

Counties with less vehicle population such as Hamilton and Knox county would have to charge higher consumer fee to balance relatively fixed administative costs.

Section 7

BENEFIT ANALYSIS

This section presents benefit analysis derived from the I/M program. Particular attention is given to the following:

- Expected reductions in emissions
- Fuel savings
- Effect on vehicle performance and vehicle life
- Failure rate and estimated repair costs
- Value of warranty repair work performed

The primary objective of an I/M program is to reduce HC emissions in response to nonattainment air quality levels for oxidants and to reduce CO in the nonattainment areas. Important secondary benefits as noted above would result from improved maintenance to the motor vehicles inspected in the program.

It should be noted that the projected benefits of an I/M program are theoretically independent of the program administration function. All of the three alternative addressed in this report would produce the same benefits.

7.1 TAIL PIPE EMISSIONS REDUCTION

The major benefit derived from the implementation of an I/M program is the reduction of HC and CO emission from motor vehicles in nonattainment air quality areas.

Tables 7-1 and 7-2 present projected HC and CO reductions within the four counties. The first year (1982) average reductions are 5 percent for HC and 21 percent for CO. In the year 1987, average reductions are 21 percent for HC and 58 percent for CO.

7.2 FUEL SAVINGS BENEFITS

The fuel savings benefits are based upon data set forth in Section 2. Vehicle population is based upon data in Table 2-24. Table 7-3 presents fuel savings (estimated gallons and dollars) for LDVs and LDTs during 1982 and 1987. The data indicates that properly maintained LDVs and LDTs would save an approximate 8.09 million gallons at a dollar savings of 6.07 million in 1982. In 1987, the number of gallons saved would be lower (5.72 million gallons) because of increased fuel efficiency. The dollar savings would be $4.29 million.

Table 7-3. ESTIMATED FUEL SAVINGS WITH AN I/M PROGRAM

YEAR	FUEL SAVINGS[a] (In Million Gallons)	FUEL COST SAVINGS[b] (In Million Dollars)
1982	8.09[c]	6.07
1987	5.72[d]	4.29

[a] Average miles traveled per year is 11,500 miles per year.

[b] Fuel cost is assumed to be $0.75/gallon.

[c] Fleet average fuel efficiency is assumed to be 15 miles per gallon.

[d] Fleet average fuel efficiency is assumed to be 24 miles per gallon.

7.3 EFFECT ON VEHICLE PERFORMANCES AND EFFECT ON VEHICLE LIFE

The benefits associated with vehicle performance and vehicle life are presented in Section 2.5 Part II. Since the impact considerations on these benefits are difficult to quantify, no further analyses is provided beyond that presented previously.

Table 7-1. HC REDUCTION (Tons/Year)

	1977		1982			1987	
COUNTY	INVENTORY	WITHOUT I/M	WITH I/M	PERCENT REDUCTION	WITHOUT I/M	WITH I/M	PERCENT REDUCTION
Chattanooga	13,170	8,575	8,116	6	5,524	4,139	33
Knoxville	14,128	9,124	8,534	7	5,886	4,089	44
Memphis	28,301	19,259	18,091	6	12,722	9,118	40
Nashville	22,371	14,723	14,333	3	10,088	6,774	49
TOTAL	77,970	51,681	49,074	5	34,220	24,120	42

Source: State of Tennessee, Department of Transportation.

Table 7-2. CO REDUCTION (Tons/Year)

	1977		1982			1987	
COUNTY	INVENTORY	WITHOUT I/M	WITH I/M	PERCENT REDUCTION	WITHOUT I/M	WITH I/M	PERCENT REDUCTION
Chattanooga	103,940	79,351	68,297	16	50,577	35,379	43
Knoxville	114,708	84,561	70,469	20	54,042	32,618	66
Memphis	194,164	179,319	151,522	18	118,180	75,256	57
Nashville	180,183	135,302	104,674	29	93,184	57,090	63
TOTAL	592,995	478,533	394,962	21	315,983	200,343	58

Source: State of Tennessee, Department of Transportation.

7.4 FAILURE RATE AND ESTIMATED REPAIR COSTS

The detail data associated with the analysis for repair costs are presented in Section 2.5 Part II. The estimated repair costs are presented in Table 7-4.

Table 7-4. ESTIMATED AVERAGE REPAIR COSTS FR LDV AND HDV FOR VARIOUS FAILURE RATE FOR 1983 AND 1987; IDLE-MODE

VEHICLE CATEGORY	FAILURE RATE (%)	YEAR[a] 1977 ($)	1983 ($)	1987 ($)
LDV	30	35.50	54.00	70.00
	35	34.00	51.00	67.00
	50	31.00	46.50	61.00
HDV	30	47.00	70.50	92.50
	35	45.00	67.50	88.50
	50	41.80	61.50	80.50

[a] To the closest $0.50.

The above table was based on the following assumptions:

1. An annual 7 percent inflation rate. The compound factor 1983 and 1987 is 1.50 and 1.967, respectively.
2. Average repair costs (1977) were projected from data in Section 2.
3. Uncontrolled vehicle repair costs are approximately 58 percent higher than costs for controlled vehicles.
4. The average repair costs do not take into consideration major repairs. The maximum repair limit is $75.

7.5 VALUE OF WARRANTY REPAIR PERFORMED

The benefits associated with the effects on the value of warranty repair completed is difficult to quantify and no further analysis was completed beyond that presented in Section 2.5 Part II. Most warranty repair is completed because of vehicle driveability problems.

The warranty failure that would be picked up in an I/M program are those exclusively installed for emission reduction.

Section 8

INDEPENDENT PROGRAM VARIABLES

8.1 ENFORCEMENT

This section will examine proposed enforcement mechanisms that could be adopted to compel vehicle owners to comply with requirements outlined in the Tennessee SIP. The analysis will address two enforcement alternatives related to light-duty vehicles, specifically, 1) withholding vehicle registration, and 2) change of ownership.

8.1.1 Vehicle Registration

The Tennessee Vehicle Registration System provides for a fully computerized and efficient data-handling system that continuously processes detailed information on owners (name, sex, age, driving history, etc.) and vehicles (make, model, year). This information is constantly updated and is readily available to governmental agencies directly concerned with I/M program requirements. These factors identify the vehicle registration system as a likely candidate for an emission test enforcement control point.

The vehicle registration system could provide for an annual inspection process by making an emission test a necessary prerequisite for the successful completion of the registration process. Upon receipt of vehicle registration renewal application, the owner could be required to obtain a Certificate of Compliance from a Certified Emission Test Station within a specified period of time (e.g., 30 days). A condition of noncompliance could result if the vehicle owner:

- Ignores emission test requirements

- Fails to pass established emission test standards

- After failure of emission test, does not obtain the necessary repairs and retest.

Noncompliance could result in nonregistration of the vehicle and, in effect, deny the right to operate the vehicle.

8.1.2 Change of Ownership

As a prerequisite for transferring the title, the new owner could be required to supply a Certificate of Compliance demonstrating that the vehicle complies with established emission standards.

8.2 REPAIR ANALYSES AND CONSUMER PROTECTION

This section reviews major program components, needs, and problems associated with a comprehensive emission repair consumer protection effort. These requirements include:

- Designation of lead agency to assume overall consumer protection responsibility.

- Implementation of consumer protection programs and issues.

- Regional responsibility of consumer protection implementation.

8.2.1 Lead Agency Designation

Prior to I/M implementation, the Tennessee State Legislature should expand the administrative authority of the Consumer Affairs Office (CAO) or its equivalent office to include a comprehensive emission repair consumer protection program. This would enpower the CAO to develop and establish procedures to implement warranty protection standards and guidelines requiring:

- The repair and/or replacement of emission control systems during the warranty period.
- That vehicle manufacturers produce durable, maintenance free emission control devices.
- Recall and field repair programs when justified by an unusual number of failed emission control devices.
- That replacement components are available and not inferior to the Original Equipment Manufacturer's (OEM) equipment.

The CAO could also institute procedures to review complaints that relate to emission control component failures and could cooperate and assist other departments associated with I/M programs that are germane to consumer protection. Finally, the CAO could institute certification/qualification criteria of service industry emission repair.

Additional responsibilities that relate to I/M program requirements and needs include the areas of:

- Education - assists in the development of consumer education programs.
- Hearings - conducts public hearings that involve emission repair rules and regulations.
- Promotion - promotes ethical standards of business conduct in the emission repair industry.
- Information - Advises the public, the Governor, and the Legislature on all matters that affect on-going I/M requirements.

- Representation - represents the consumer's interest before Federal and State Legislative hearings and executive commissions.

8.2.2 Implementation of Emission Repair Consumer Protection Program

The proposed emission repair consumer protection program may be summarized under the following categories:

- Warranty protection
- After-market parts program
- Modified parts program
- Recall/defects program
- Consumer complaint program
- Certification of repair facilities
- Repair cost ceilings
- Public information program

A brief description of the scope of the emission repair consumer protection program for each category follows:

Warranty Protection - The Motor Vehicle Emission Control Office (MVECO) or its equivalent office could develop and establish regulations to ensure that vehicle owners are protected from abuses related to the 24-month, or 24,000 miles, warranty provision set forth in the Emission Control System Performance Warranty of Section 207(b) of the Clean Air Act 1977 Amendments. The Emission Performance Warranty further requires the automobile manufacturer to warrant the catalytic converter, thermal reactor or other components installed on or in a vehicle for the sole or primary purpose of reducing emissions for a period of 50,000 miles or 5 years, whichever comes first.

The manufacturer must bear the cost of repair of any properly maintained and operated vehicle which fails an EPA-established emissions test within 24-month/24,000-mile or 5-year/50,000-mile, as appropriate.

After-Market Parts Program - This program is separate and distinct, and could be reviewed in light of the effect of such parts on emissions control.

The replacement parts manufacturer could be responsible for the original equipment performance requirements to ensure a continuity in emissions control.

Modified Parts Program - Provisions could be made to ensure that vehicle owners do not install equipment such as bleeder valves which may have a decided effect on emissions. Such a program may require that equipment be certified by the state as not having a significant effect on emissions prior to the sale of such products within the state.

Recall and Defects Program - Consideration is required with regard to the follow-through of recall and original manufacturer's defective parts programs as to how each problem relates to test site operation and follow-through assurance that the dealerships respond to the installation requirements of related repairs. These do have a decided effect on emissions in many cases.

Consumer Complaint Management - In the initial phases of the I/M program, some complaints may emanate as a result of inspection procedures and personnel, but it is more likely that the majority of complaints will be in relation to repair actions. It is important that these complaints are processed rapidly and acted upon within a reasonable period of time. If justified complaints are not resolved to the satisfaction of the consumer, adverse public reaction to the I/M program concepts may result.

The CAO could provide efficient mechanisms to process complaints concerning warranty protection, overcharging and unnecessary repairs by individual garages, as well as complaints about the program in general. These mechanisms would include: 1) a statewide information and referral system available through a toll free number, and 2) complaint forms available at each inspection facility. Once the complaint is received through other processes, a consumer representative would attempt to resolve the problem over the telephone. If the complaint is not resolved to the satisfaction of both parties, the consumer representative could refer the matter to the MVECO for further arbitration.

In addition to the complaint service, the Automotive Division of the CAO could maintain permanent records of consumer complaints on each repair facility.

If too many complaints about any one facility are received, the CAO could investigate, and revoke the license of the garage if the claims were justified.

Certification of Repair Facilities - Ultimately, an I/M program can accomplish emission reduction only if it increases the frequency and quality of vehicle maintenance than would have occurred voluntarily. Clearly, the quality of the maintenance performed in response to emission inspection failure will have an important impact on I/M program effectiveness and cost. The performance of service garages participating in emission repair work has been evaluated from two viewpoints. One viewpoint has considered the capability of repair agencies to perform emission-related work; and the second, the extent of unwarranted repair, and the resultant unnecessary cost burden.

A recent California study has examined the ability of repair facilities to follow Motor Vehicle Inspection Program (MVIP) repair procedures for dealerships, service stations, and independent garages. Table 8-1 presents data indicating that of those repair facilities surveyed, approximately 26 percent and 56 percent did not follow established repair procedures for idle and loaded tests, respectively. Also, it was found that when repaired vehicles were returned for reinspection, approximately 16 percent (idle) and 29 percent (loaded) failed emission retest (Table 8-2). This suggests that there is need for close supervision of emission repair facilities.

In view of the above information, the Motor Vehicle Emission Control Office could establish stringent certification and qualification criteria for emission repair garages. Repair garages approved for emission repair work must:

- Employ at least one mechanic certified to perform emission repair work.

- Own or lease analyzers capable of accurately measuring HC and CO levels.

- Provide incentives for mechanic retraining every 1 to 2 years.

Table 8-1. ABILITY OF REPAIR FACILITIES TO FOLLOW THE MVIP REPAIR PROCEDURES

	IDLE REGIME		LOADED REGIME		BOTH REGIMES	
	Total Repaired	Did Not Follow Repair Procedure	Total Repaired	Did Not Follow Repair Procedure	Total Repaired	Did Not Follow Repair Procedure
Dealerships	34	7 (21%)	83	51 (61%)	117	58 (50%)
Service Stations	24	9 (38%)	117	57 (49%)	141	66 (47%)
Independents	87	22 (25%)	96	58 (60%)	183	80 (44%)
ALL	145	38 (26%)	296	166 (56%)	441	204 (46%)

Table 8-2. REPAIRED VEHICLES WHICH FAILED REINSPECTION

IDLE REGIME	TOTAL REPAIRED	FAILED FIRST REINSPECTION	WAIVED	FAILED FIRST REINSPECTION, EXCLUDING WAIVED VEHICLES
Dealerships	34	0 (0%)	0 (0%)	0 (0%)
Service Station	24	6 (25%)	3 (13%)	3 (13%)
Independents	87	17 (20%)	8 (9%)	9 (10%)
ALL	145	23 (16%)	11 (8%)	12 (8%)

LOADED REGIME	TOTAL REPAIRED	FAILED FIRST REINSPECTION	WAIVED	FAILED FIRST REINSPECTION, EXCLUDING WAIVER VEHICLES
Dealerships	83	20 (24%)	10 (12%)	10 (12%)
Service Stations	117	36 (31%)	20 (17%)	16 (14%)
Independents	96	30 (31%)	13 (14%)	17 (15%)
ALL	296	86 (29%)	43 (15%)	43 (15%)

In addition to the above qualifications, each garage should serve a minimum probationary period of at least 1 year. This should include close supervision of the repair operation using correlation vehicles and referee stations to check the adequacy of repair maintenance.

Repair Cost Ceilings - Another responsibility of the MVECO includes the regulation of emission repair costs. This would be accomplished by fixing maximum price ceilings on all emission repair work. Table 2-23 examined the effect of reducing the maximum repair cost ceiling on percentage of failures repaired, average repair cost, average fuel economy, and total emission reduction. For example, as the maximum repair cost is reduced from $150 to $100 ($10 increments) there are no observed reductions. However, if the maximum repair cost is lowered below $100 (baseline), there are 2 percent to 4 percent reductions in every category. This seems to indicate that there is a compromise point between what the public is willing to pay (repair cost ceiling) and the desired level of emission reduction, fuel economy, and average repair cost.

Once the maximum repair cost ceiling is established, vehicles with consumer repair work exceeding the cost ceiling would be exempt. This avoids placing undue economic hardships on owners. The cost of exempting certain vehicles from having emissions-related repair work performed is the reduction in the overall effectiveness of the program. Given the relatively small percentage of major emissions-related repair work, however, it would appear that little decrease in overall emissions reduction would result from the exemption of some vehicles. This is based upon the fact that in Oregon and Arizona only 2 percent of the tested vehicles cost more than $100 to repair. In New Jersey, the figure was 5.6 percent. It would appear, therefore, that the gains in terms of public acceptance would tend to outweigh any decrease in emission reduction resulting from the waiving of repair requirements for certain vehicles.

Recent studies have shown that the average repair cost is estimated to be within a range of $26 to $34 for idle/loaded test regimes, prior to year 1975 (Table 8-3). In addition, there is a $2 to $8 overcharge that is directly attributable to unnecessary or unwarranted repair work. This problem can be

Table 8-3. AVERAGE REPAIR COSTS - FAILED VEHICLES[a]

	IDLE TOTAL	IDLE OVERCHARGE	LOADED MODE TOTAL	LOADED MODE OVERCHARGE	= DEFINE
California Study (Ref. 35)	$21	$2	$23	$5	35%
Northrop (Ref. 19)	$34	-	$30	-	50%
EPA (Ref. 41)	$26	$8	$28	$7	50%
Olson (Ref. 23)	$26	-	-	-	50%

[a] Unadjusted dollar costs in various years.

remedied only if the inspection station provides accurate diagnostic and price information for the consumer.

All repair costs in Table 8-3 were from study results. The recent Arizona I/M experience revealed that the average cost of repairs to failed vehicles was $23.02 during 1977. These costs ranged from zero for warranty repairs to cover $600 for an engine overhaul. Table 8-3 presents the average cost of repairs for various model year groupings versus facilities performing the repairs. The analysis of total repair costs indicated that 50 percent of the vehicles were repaired for less than $11.25.

In turn, the consumer could go to an approved repair facility and request specific repairs, fully confident that an established price will not be exceeded.

Public Information Program - Many questions raised by I/M implementation could be properly addressed through a well-designed and comprehensive public information program. It could help to eliminate adverse public criticism by stressing the purpose, objectives, benefits, and operation of I/M. Emphasizing the checks and balances (e.g., quality assurance) designed into the I/M program and health benefits from emission reductions could alleviate many problems associated with the implementation procedure.

A public information program could address other benefits to the vehicle owner. Improvements on fuel economy, vehicle performance and longevity are important to vehicle owners. Control of vehicles that emit annoying quantities of smoke, and assurances that I/M requirements will extend to all vehicles are important points to stress.

This could be accomplished by effective use of advertising techniques that utilize the mass communication media (e.g.; radio, television, newspapers, etc.), information centers, education programs, citizen group contacts, etc. In the early stages of I/M implementation, initial program information should include:

- Explanations that outline control procedures and derived benefits from automotive emission controls.

- Explanations of what automotive equipment requires inspection.

- Identification of the most common causes for emissions failure.

Supplemental information is required after the public has accepted the need to understand the concepts of I/M. This additional information includes:

- The location of test facilities.

- Instructions and fee requirements.

- Explanation of retest requirements and conditions.

- Importance for allowing time for repair, and retest, or considerations for waiver.

- Explanation of complaint referral system.

8.2.3 District Responsibility of Consumer Protection Implementation

The responsibility of implementing an emission control consumer protection program on a regional basis would belong to the "Emission Control Investigative Unit" (ECIU) or equivalent--the investigative arm of the Vehicle Inspection Office. The primary function of the ECIU would be to prevent fraudulent automotive emission repair practices on vehicles identified as having failed to meet emission standards. These fraudulent emission repair practices include overcharging and performing unnecessary or unwarranted repair work. Under an I/M program requirement, the automotive emission repair dealer could be required to:

- Supply the consumer with a written estimate before any emission repair is performed. The estimate is calculated by using state established emission repair prices.

- Obtain authorization for any expense in excess of the original estimate, and not to exceed the maximum repair price ceiling.

- Provide the consumer with an itemized invoice clearly showing all labor and parts supplied. This fully informs the consumer of the cost and nature of the emission repairs performed on the vehicle.

- Refrain from false advertising, misleading statements, or promises intended to induce an uninformed consumer to agree to unnecessary repairs.

The ECIU accepts and processes complaints that involve infractions of any of the above four regulations. Consumer representatives of the CAO operate a statewide information and referral network through which consumers may register their complaints. An attempt is made by the consumer representative to satisfy the complaint by contacting the emission repair dealer. If there is no agreement, the complaint is referred to a field investigator of the ECIU. The responsible investigator could meet with the consumer and repair dealer and, in some instances, examine the repair work to ensure that provisions of the law are satisfied. Under unusual circumstances, investigators may at their discretion use a specially outfitted surveillance vehicle to check the integrity of emission repair work. If there is sufficient evidence of consumer fraud, the matter could be turned over to the CAO for further investigation, and possibly prosecution.

The ECIU could also have the responsibility of testing and licensing individual facilities as official emission repair stations. When an automotive repair facility employs an individual trained in emission control equipment repair, and owns or leases approved emission HC/CO analyzers, the facility may apply for a license as a State Approved Emission Repair Facility. Field investigators could make periodic checks of all licensed stations to inspect all phases of emission repair work. Any irregularities in the operation, quality of repair work, pricing, etc., may result in revocation of the license.

In cases that involve flagrant violations of consumer rights, the ECIU may request that the CAO begin proceedings against certain repair facilities.

It should be anticipated that many cases could be settled by decree or voluntary compliance. However, when there is evidence of serious violation, cease and desist orders could be sought. The CAO could decide whether a formal complaint is required, enter into a consent settlement and, if necessary, try the case before a hearing examiner. Where consumer abuse is localized, the CAO could establish a liaison with and refer the matter to municipal or county authorities for possible criminal investigation.

8.3 QUALITY ASSURANCE

8.3.1 Inspection and Maintenance Equipment Standards

The equipment standards are classified and discussed according to the two following categories: sampling system considerations and selection, and gas analyzer considerations and selection. The sampling system and gas analyzer considerations sections discuss the various technical problems and solutions associated with the analysis of vehicle exhaust gas emissions. The selection sections discuss the basic requirements for the equipment to adequately perform the analysis.

Included in this section is a table giving relevant information concerning a small sample of gas analyzer systems currently available and suitable for an I/M program. Within this information are specifications defining the ambient conditions necessary for valid emission analysis.

Sampling System Considerations - Exhaust gases are extremely complex mixtures of HC, CO_2, CO, NO_x, aldehydes, particulates, water, nitrogen, oxygen, hydrogen, and many other compounds. To accurately measure any single pollutant, the application of proper gas sampling techniques and careful sample handling treatment prior to instrument analysis are required. The basic consideration must be to obtain a sample of exhaust gas which is completely representative of the vehicle exhaust for the operating condition of interest.

It becomes necessary to selectively remove those materials and compounds which may affect the absolute measurement of the subject pollutant without changing the concentration or characteristics of that pollutant. In a practical sense, this generally means reducing the water vapor level in exhaust gases and filtering out the particulates before passing the gas sample through a measuring instrument. Additionally, the sample handling system must also provide for the periodic inputting of zero and span check gases and calibration gases.

Sampling System Selection - The sampling system may consist of a tail pipe probe, sample line, vapor condensor, particulate filter(s), sample pump and appropriate valves for the check and calibration cycles and for purging the system. In the definition of a sampling system, the following need to be considered:

- Avoidance of materials that are subject to corrosion, deterioration and HC hang-ups.
- Adequate flow rates for fast system response.
- Rugged construction of sample lines and probes to withstand heavy usage.
- Filtering system of adequate capacity and serviceability.
- Adequate provisions for water removal.

Gas Analyzer Considerations - The heart of any automobile exhaust emission test system is the instrument component required to measure the levels of pollutants. Depending on the type of test being conducted, the analyzers will vary from relatively simple and inexpensive to highly sophisticated versions.

A large number of sophisticated exhaust gas analysis systems have been assembled and used in research programs and in the certification and quality audit of new cars to evaluate their compliance with state and Federal standards. At the other end of the spectrum, some relatively simple analyzers are being used by garage mechanics and tune-up technicians to assist in adjusting engine operating parameters during maintenance. The instrument system required in a mandatory inspection program probably lies somewhere between these extremes.

Typical Gas Analyzer Selection - For I/M applications, prior to the selection of the exhaust emission analyzers, the emission inspection limits should be reviewed to ensure that all necessary ranges are considered. With the introduction of catalytic reactors and other refinements on new vehicles to comply with emissions standards, engineering estimates should be used to predict the measurement levels anticipated in the near future. Other factors to be considered in defining instrument specifications include accuracy, speed of response, stability, effect of interference gases, ease of operation, and maintenance.

Carbon Monoxide - The most commonly used method for CO measurement in exhaust analysis is the nondispersive infrared (NDIR) technique. These instruments are based on the principle that the infrared absorption spectrum of the measured gas is sufficiently unique as compared to any other exhaust component gas, and that measurement of infrared energy absorption is proportional to the concentration of the component of interest in the presence of other gases.

The sensitivity of the NDIR instrument is proportional to the physical length of the sample cell. CO monitors have been built for ambient air monitoring which can detect CO in the 1 ppm range. The sensitivity requirement for exhaust CO analysis is much less severe because the concentrations in exhaust gases are orders of magnitude higher than in the atmosphere.

On the high end, CO is occasionally observed in the exhaust gases of uncontrolled (pre-1968 model) cars in concentrations above 10 percent. On the low end of the range, some properly tuned and adjusted engines on controlled cars will produce CO concentrations lower than 0.1 percent during idle and cruise modes of operation. Thus, the CO instrument should provide accurate readouts over the range of 0 to 10 percent. A preliminary conclusion is that the CO analyzer required for the mandatory inspection program will require two or more gas concentration ranges from 1 to 10 percent.

Hydrocarbons - The analysis of HC in automotive exhaust gas is complicated by several factors. HC are a complex mixture and their concentrations vary over an exceptionally wide range. The NDIR technology may also be used for HC measurements or, as in current Federal mass testing, the Flame Ionization Detector (FID) is used.

NDIR analyzers using detectors sensitized with N-hexane had been the standard for measurement through 1971. FTP for 1972 and subsequent years specified use of FID due to the higher sensitivity required for dilute exhaust gas measurement. Neither instrument method is clearly superior and either method can be incorporated into a mandatory inspection program. Presently, the NDIR analyzer has been most successfully adapted to a relatively low-cost rugged analyzer for inspection use, but the characteristics of FID analyzers need to be examined also.

FID instruments are significantly different from NDIR analyzers in that they measure the total HC present in a sample of exhaust gas. The FID method also can be electronically switched over a wide concentration range making only one instrument necessary in those test modes which require high dynamic range. The measurement of total HC is, however, not necessarily desirable for two reasons:

- Methane contributes to the response in the FID instrument; but, being a nonreactive component, it is debatable whether it should be included in HC measurement.
- Since the NDIR method is the only one used at the repair shop level, and the NDIR does not respond to methane, correlation between the inspection station and repair shop would be questionable if the FID were used for inspection.

Another important consideration in the selection of the instrumention is the wide range of values required to measure HC concentration in the various modes of vehicle operation. During vehicle testing, HC concentrations of a few thousand ppm are commonly observed and, occasionally, values in excess of

10,000 ppm are observed. Conversely, observed values of less than 50 ppm are common in the exhaust of well adjusted 1972 to 1974 emission controlled cars operating in steady-state modes; even lower values are observed with 1975 and later vehicles.

For the I/M exhaust emission program, the NDIR analyzer is probably the best choice because it is reasonably stable and trouble free. Calibrations and maintenance procedures are well defined and their effectiveness well established. Many thousands of these instruments, produced by several major manufacturers, are being used very successfully in automotive exhaust emissions analysis.

For the final analyses, the selection of HC instrumentation depends on the degree of measurement accuracy and ranges required based on an evaluation of the exhaust emissions inspections standards established by the state. Table 2-4 provided information concerning a small sample of exhaust emission analyzers suitable for use in an I/M program.

8.3.2 Inspection System Quality Assurance Plan

The Quality Assurance Plan is classified according to the four following categories: daily operational checks and adjustments, scheduled preventive maintenance, major maintenance and repair, and periodic instrument calibration checks. The first two categories are conducted on a routine, as-required basis and are performed during normal working hours by inspection facility personnel. Major maintenance should be available on an on-call basis by fully trained service personnel supplied by the appropriate instrument manufacturing company. The major maintenance service personnel would repair and overhaul major equipment and have available a complete stock of spare parts and major equipment replacement units. Periodic instrument calibration checks would be performed by qualified state inspectors dispatched from a central state-operated facility. The state inspectors would conduct the calibration checks using a fully equipped mobile test unit.

Daily Operational Checks and Adjustments - Daily operational checks of the vehicle inspection system would be performed by inspection facility personnel prior to opening for business. The daily operational checks schedule is shown in Table 8-4.

Table 8-4. DAILY OPERATIONAL CHECKS AND ADJUSTMENTS

CHECK	ADJUSTMENT	MAINTENANCE
NDIR Gas Analyzer	Zero and Span. One/shift by the supervising inspector and one per six tests by inspection personnel	None
Sample Handling	Temperature, flow and pressure check once/shift by inspection personnel	Replace filters or damaged sample probe as required
Working gases	Turn on gas and adjust output pressure if necessary	Check cylinder gauge pressure and replace gas cylinder as required

The NDIR CO/HC analyzers require initial zero and span check to verify that the test lane operational status is according to specifications. The NDIR gas analyzers would be zeroed and spanned manually at the beginning of each work shift by the supervising inspector or surrogate. For the remainder of the shift, the inspector should compensate for minor zero or span shifts once every six tests. Repeated zero and span drift error will require that the analyzer receive first echelon maintenance.

At the beginning of each shift, the temperature of the water bath would be checked and adjusted as required. The pressure and flow of the exhaust sampling system would be checked and adjusted to specified values by the supervising inspector or other inspection personnel. Cylinder pressure of the working gases (zero and span for the NDIR analyzer) would be checked each shift and new cylinders will be installed by the facility personnel if the pressure drops below 100 PSI.

Scheduled Preventive Maintenance - Preventive maintenance of the vehicle inspection system would be accomplished on a scheduled basis and integrated into the daily operational checks by the inspection facility supervising inspector.

Preventive maintenance for the sampling system would be performed at the beginning of each shift. The tail pipe sample probe and sample line would be checked for damage and restricted sample flow. The water trap and aspirator would be checked for deposits and cleaned as required. The exhaust gas filter would be checked and replaced as required.

The preventive maintenance for the analyzers would be performed periodically as specified by the instrument manufacturer.

First Echelon Repair - Daily operational checks and adjustments or periodic calibration and preventive maintenance activities may reveal a functional problem or a defective component. The inspection facility personnel would perform the required maintenance when the problem can be readily isolated down to available spare parts. Two categories of spares would be maintained: (a) operating disposable spares including filters, and (b) field replaceable spares including indicator lights, fuses, and sample probes. All repair activities would be in accordance with equipment manufacturer's repair and adjustment procedures.

Major Maintenance - Those system failures which cannot be corrected by inspection facility personnel due to problem complexity, spare parts, or troubleshooting instrumentation, would be referred to the appropriate manufacturing company responsible for major maintenance. The inspection facility supervising inspector would inform the manufacturer of the problem, provide a detailed description of the malfunction and describe the impact on vehicle testing. Based on these descriptions, the manufacturer would dispatch the skilled service personnel and required resources to accomplish the field repairs.

To perform the vehicle inspection systems repair and to limit system downtime, components for the systems would be maintained by the manufacturer. When a system failure occurs and the failed component can be promptly identified by the vehicle inspection facility, the replacement component would be dispatched from the manufacturer so that the equipment can be repaired and recalibrated.

Periodic Calibration Checks - Periodic calibration checks would be performed at 90-day intervals. These periodic calibration checks would be performed by qualified state inspectors. The state inspectors would operate out of a mobile test unit dispatched from a centrally located state facility. The mobile test unit would be equipped with an NDIR gas analyzer, remote tachometer, ±1 percent calibration gases, tachometer calibrator, field-type diagnostic equipment and field replaceable spare parts. For customer and facility owner convenience, the calibration checks would be prearranged to allow for scheduled downtime. The expected downtime involved for each facility calibration check is one hour, providing that no problems are encountered. The periodic calibration check schedule is shown in Figure 8-1. In the case of privately-owned facilities, additional periodic unannounced/unscheduled calibration checks will be performed using state-owned correlation cars.

The remote tachometer calibration check would be performed using the tachometer calibrator, necessary adjustments and repairs would be made per manufacturer's specifications.

The NDIR gas analyzer would receive a 5-point calibration test with ±1 percent certified calibration gases; all necessary adjustments and maintenance would be made per manufacturer's specifications.

A correlation test would then be performed using the state mobile unit as the test vehicle. The mobile unit would receive one emission test using the facility instrumentation and one emission test using the state-owned instrumentation located on board the mobile test unit. The emission test results would then be compared for accuracy.

If the calibration check and correlation test results are within the specified range, the inspection facility would receive a 90-day certification. If the inspection station fails the calibration check and/or the correlation

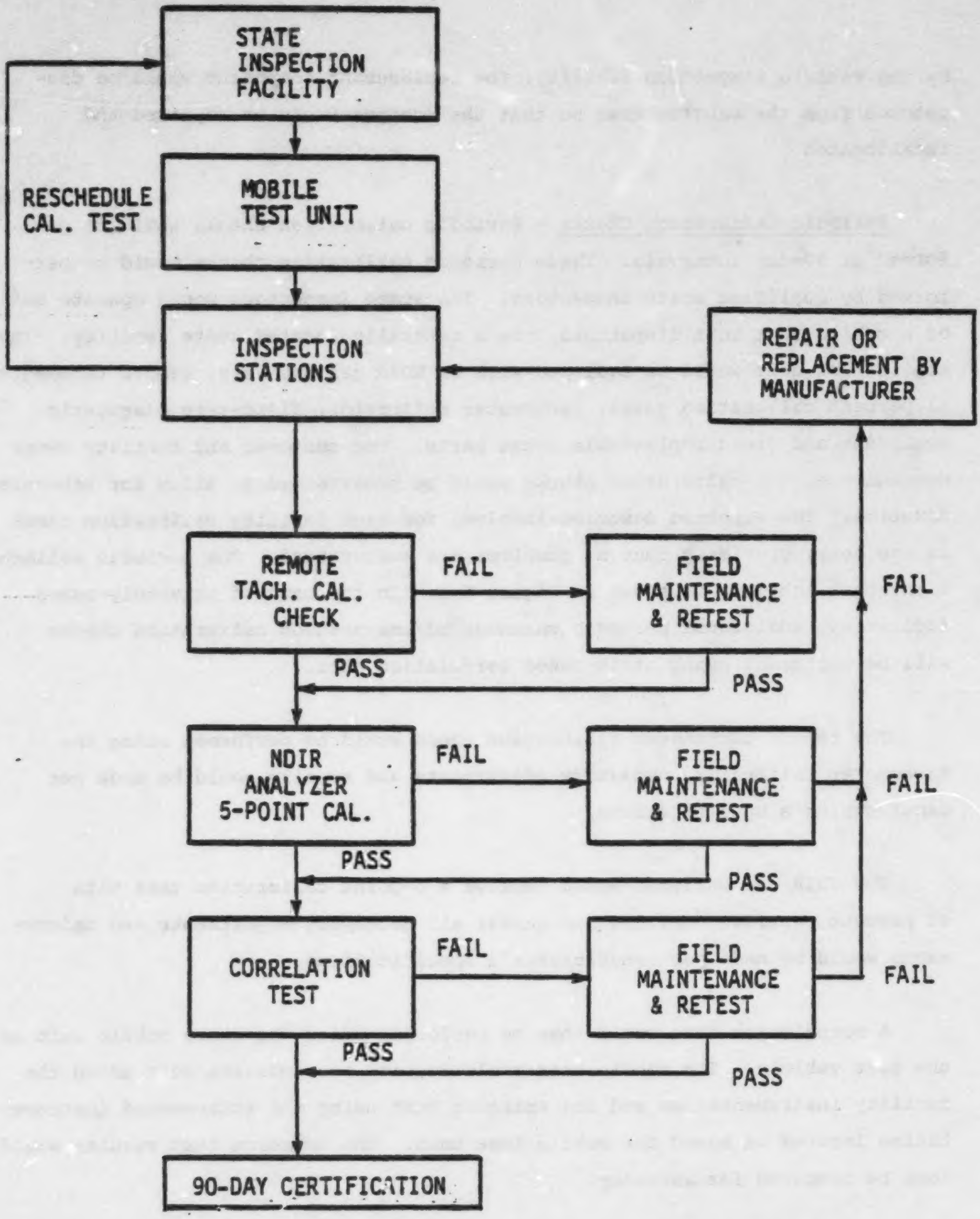

STATE INSPECTION FACILITY
MOBILE TEST UNIT
RESCHEDULE CAL. TEST
INSPECTION STATIONS
REPAIR OR REPLACEMENT BY MANUFACTURER
REMOTE TACH. CAL. CHECK
FAIL
FIELD MAINTENANCE & RETEST
FAIL
PASS
PASS
NDIR ANALYZER 5-POINT CAL.
FAIL
FIELD MAINTENANCE & RETEST
FAIL
PASS
PASS
CORRELATION TEST
FAIL
FIELD MAINTENANCE & RETEST
FAIL
PASS
PASS
90-DAY CERTIFICATION

Figure 8-1. STATICN CERTIFICATION PROCEDURE

test, it would not be recertified and, therefore, would not be able to perform emission testing. It would then be the responsibility of the facility to have the equipment corrected and to contact the Motor Vehicle Division (MVD) to be rescheduled for calibration testing.

Privately-owned emission test facilities could receive periodic unannounced/unscheduled calibration checks. State-owned correlation cars could be adjusted in such a way as to produce high emissions of HC or CO; for example, by adjusting the carburetor air/fuel mixture to produce high HC and low CO exhaust emissions. The correlation car would then receive an emission test at the state facility and be dispatched to a privately-owned facility. The correlation car would then receive a normal I/M test at the private facility and the results of the emission test will be compared to those generated by the state facility. If the correlation test results are not within the specified range, the MVECO would contact the facility owner and arrange for a complete calibration check and recertification of the facility.

Referee Vehicle - Customer complaints may arise regarding the reliability of emission test results, especially in cases where a vehicle fails an emission test after the recommended repairs have been performed. In order to resolve complaints of this nature, a referee test station could be used. For convenience to the customer and the MVD it is recommended that the mobile test units which are used for periodic instrumentation checks, also be used as referee test station. Upon receipt of a customer complaint and request for verification of emission test results, an appointment would be made to conduct the verification test at the test facility in question. The appointment time can be arranged in such a way as to be convenient to the mobile test unit, perhaps when the unit is in the general location performing its usual task. The result of the verification test conducted by the state inspectors should be final.

To avoid an overload on the system, specific criteria would have to be developed to single out complaints of possible validity for verification testing. For example, vehicles which have failed after the recommended repairs were performed and/or vehicles for which the recommended repair costs are above some predetermined level would be eligible for verification testing.

8.4 DATA MANAGEMENT SYSTEM DESIGN

Data management encompasses the flow of data from primary source to ultimate use. The mandatory vehicle emission inspection program may be broken down into three data management subsystems:

- Vehicle owner notification
- Vehicle inspection and repair
- Program effectiveness

These will be discussed separately with the interface between each pair identified. Differences in data handling procedures for state-, contractor- and private-operated facilities will be indicated.

Vehicle Owner Notification - Satisfactory completion of a vehicle emissions inspection would be required prior to initial and annual motor vehicle registration. Annual registration should be accomplished on a month-to-month basis. Notification of registration renewal should be supplied to the owner approximately 2 months prior to the final date for renewal. This would provide sufficient time for the owner to have his vehicle inspected, to have any required repairs completed, and to be retested. The most expedient way to notify the owner of the inspection requirement would be as part of the automobile registration renewal packet.

Two items of information would be required for inclusion in this packet:

- An explanation of the requirement and instructions for accomplishment of the inspection.
- A Vehicle Identification (VID) card to be used by the inspection facility to identify the vehicle and applicable exhaust emission data; e.g., emission control device(s) installed, appropriate emission levels, etc.

Vehicle Identification Card (VID) - A VID card should be provided which contains sufficient information to identify the vehicle to be inspected. This fixed information could be recorded on the inspection report form along with variable information such as odometer reading and inspection number. The VID card should be presented in legible condition, along with the automobile registration renewal card, to the inspection facility personnel prior to inspection. Lost VID cards should be duplicated at the facility office. In no case would a vehicle be tested without this documentation. The two documents and the vehicle should be compared for accuracy and for missing data.

At the beginning of the inspection program, it is known that some of the data required for accomplishing the inspection will not be available from the DMV. Missing data may include:

- Vehicle weight class
- Emission control systems installed
- Number of cylinders
- Applicable emissions standard code

These should be determined at the initial inspection and marked on the VID card. It could also be noted on the automobile registration card retained by the owner and on the portion retained by the MVD so that their files can be updated.

It should be the vehicle owner's responsibility to safeguard this VID card for use at subsequent vehicle inspections (e.g.; next annual registration, installation of a different model-year engine or an engine with a different number of cylinders, change of ownership, etc.). Should any of the information on the card require a change, it would be necessary for the vehicle owner to go to a designated site to obtain an updated card. Should the owner lose or destroy his card, he should be required to pay a fee for its replacement. This will entail the transcript of information from his automobile registration card and perhaps a physical inspection of the vehicle if data are missing.

Safeguards Against Fraud - It is reasonable to believe that some persons might try to beat the system by altering the information on the VID card to put the vehicle in a less stringent emission standards category and/or change the emissions control system requirement code. This can be overcome by using a card on which is imprinted the state insignia and by using special codes for identifying applicable standards and emissions control systems required.

Use in Identifying Retests - It would be necessary for a failed vehicle to return to the inspection facility at which it failed for a retest after repair. This would ensure that corresponding inspection and repair data are collected and greatly simplify data handling. Proper forewarning should reduce any inconvenience to the motorist.

Other persons might also use the inspection system as a low-cost diagnostic center whenever they suspected a problem with their vehicle. In one sense this is good, if a high polluting vehicle is detected and repaired voluntarily, but this places an unnecessary burden on the system.

Keeping track of the number of inspections is important, and it may become necessary to charge an additional fee for retests above some basic quantity, to discourage inefficient or ineffective repairs.

An effective method of accomplishing all of these safeguards would be to use a stamping device, much like a timeclock, to imprint the VID card with the facility number, date and time of an inspection. It would then be easy for the inspector to determine whether the vehicle was in for a retest, since only a short period (less than 2 months) would have elapsed since the last stamped test, and if he were at the correct facility for a retest. Approximately 12 of these imprints could be placed along the 3-1/4-inch edge of the VID card so the same card could be used through several years of inspections and retests. A replacement fee would discourage the vehicle owner from destroying his card to avoid paying a retest fee, or having to return to the facility at which his vehicle failed. Otherwise, it might also become necessary to imprint the back side of the automobile registration card as a double precaution since this would also be checked each time the vehicle was submitted for a test.

The alternative is to rely on the motorist to tell the inspector whether he is in for a retest or not. The driver, who would not necessarily be the owner, may honestly not know.

Vehicle Inspection and Repair - The data management responsibilities at the inspection facility should include the checking of registration documents to establish which emission standards are to be applied, checking the repair summary for completeness (if a retest, as noted by a recent date on the VID card) and checking certificates of retrofit installation (if required). If a retest, a copy of the previous inspection report form could be pulled from a Retest File for comparison.

Additional responsibilities could include the control of the information flow through the inspection process, the distribution of copies of the inspection reports depending on the inspection results, and the correlation of repair data with retest data. As an example, the flow of this data is shown in Figure 8-2. All hard-copy data could be retained at the facility for a period of at least 18 months.

Inspection Report Forms - The Inspection Report Form, Figure 8-3 could be completed in the following way. The information to be recorded from the VID card and visual inspection would include the year, make, model, number of cylinders, and smog code. Other information to be recorded would include license number, weight code, odometer reading, facility code and test number.

Proper installation of the original equipment control device(s) would be visually verified by the inspector. Other visual inspections will include checking the exhaust system and inspecting for excessive fluid leaks.

The results of the visual inspection would be recorded on the vehicle inspection report.

Visual Inspection Report Form - In the event that a vehicle fails the visual inspection, the Visual Inspection Report Form, Figure 8-4, would be completed. Vehicles with original equipment control devices improperly installed would be rejected without emission testing. Other reasons for rejecting a vehicle prior to emission testing are exhaust system leaks and excessive fluid leaks which could effect emission test results. One additional reason for rejection after the vehicle is in place for emission testing is excessive sample dilution due to a faulty exhaust system not detected visually.

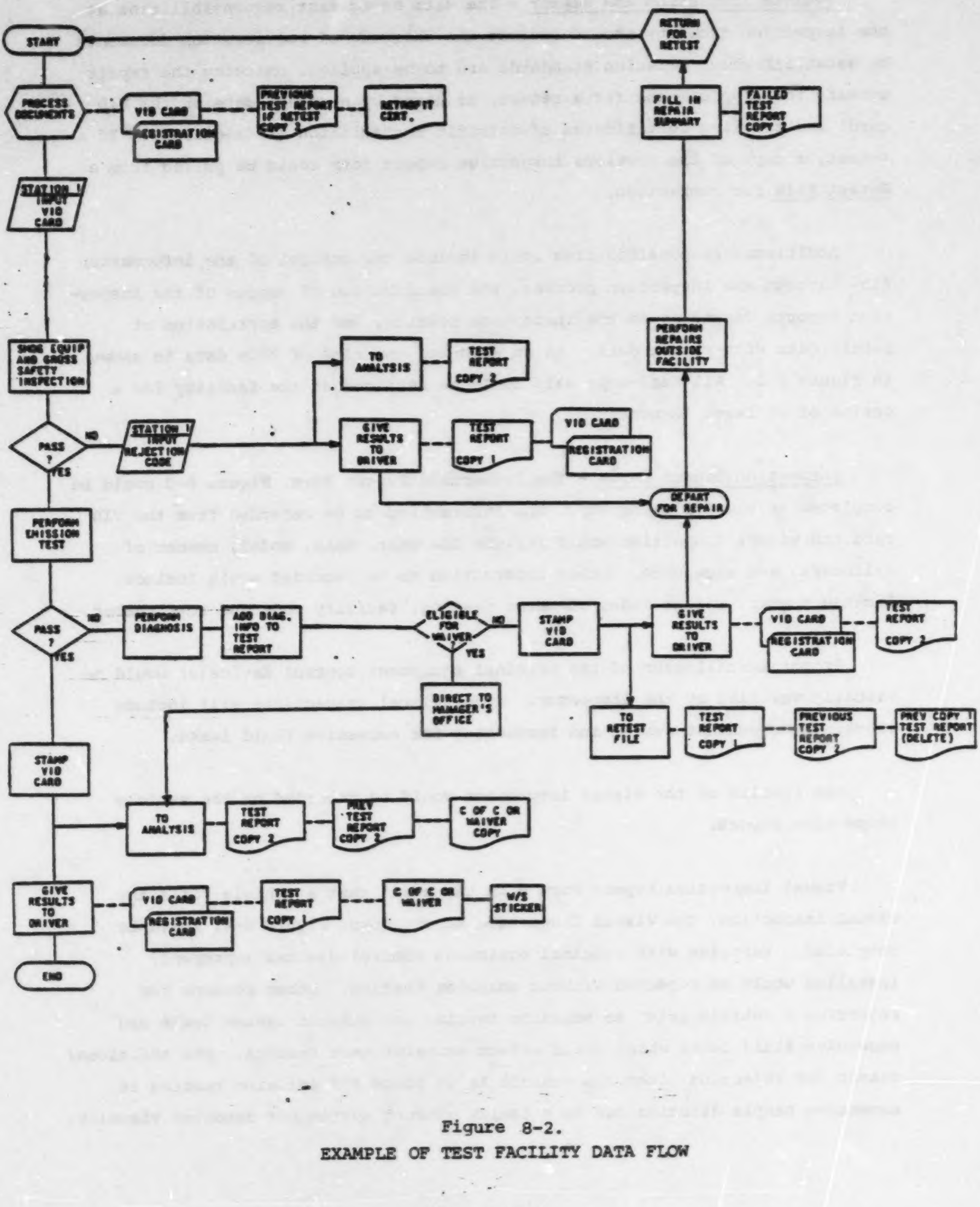

START
RETURN FOR RETEST
PROCESS DOCUMENTS
VID CARD
REGISTRATION CARD
PREVIOUS TEST REPORT IF RETEST COPY 2
RETROFIT CERT.
FILL IN REPAIR SUMMARY
FAILED TEST REPORT COPY 2
STATION 1 INPUT VID CARD
SHOW EQUIP AND GROSS SAFETY INSPECTION
TO ANALYSIS
TEST REPORT COPY 2
PERFORM REPAIRS OUTSIDE FACILITY
PASS ?
NO
YES
STATION 1 INPUT REJECTION CODE
GIVE RESULTS TO DRIVER
TEST REPORT COPY 1
VID CARD
REGISTRATION CARD
DEPART FOR REPAIR
PERFORM EMISSION TEST
PASS ?
NO
YES
PERFORM DIAGNOSIS
ADD DIAG. INFO TO TEST REPORT
ELIGIBLE FOR WAIVER ?
NO
YES
STAMP VID CARD
GIVE RESULTS TO DRIVER
VID CARD
REGISTRATION CARD
TEST REPORT COPY 2
DIRECT TO MANAGER'S OFFICE
TO RETEST FILE
TEST REPORT COPY 1
PREVIOUS TEST REPORT COPY 2
PREV COPY 1 TEST REPORT (DELETE)
STAMP VID CARD
TO ANALYSIS
TEST REPORT COPY 2
PREV TEST REPORT COPY 2
C OF C OR WAIVER COPY
GIVE RESULTS TO DRIVER
VID CARD
REGISTRATION CARD
TEST REPORT COPY 1
C OF C OR WAIVER
W/S STICKER
END

Figure 8-2.
EXAMPLE OF TEST FACILITY DATA FLOW

VEHICLE INSPECTION REPORT

INSPECTION DATE____________________

FACILITY NO.__________ LANE NO.__________

LICENSE NO.__________ YEAR________ MAKE________ MODEL__________

WEIGHT CLASS__________ CYL________ SMOG________ ODOMETER__________

FIRST TEST ☐

RETEST NO. __ ☐

TEST RESULTS:

		IDLE	2,500 RPM
HC, PPM	STD.		
	ACTUAL		
CO, %	STD.		
	ACTUAL		

☐ FAILED VISUAL INSPECTION

DECISION: ☐ PASS ☐ FAILED THOSE MODES DESIGNATED BY F

DIAGNOSTIC INFORMATION:

SEE REPAIR PROCEDURE NO. _____

MEASURED PARAMETERS AND DIAGNOSTIC MESSAGES

____

REMARKS____________________________________

____

____

INSP. NO.__________ INSP. SIGN.____________________

Figure 8-3. EXAMPLE OF INSPECTION PROGRAM REPORT FORMAT

VISUAL INSPECTION REPORT

INSPECTION DATE____________________

FACILITY NO.__________ LANE NO.__________

LICENSE NO.__________ YEAR________ MAKE__________ MODEL__________

WEIGHT CLASS__________ CYL__________ SMOG__________ ODOMETER__________

FIRST TEST ☐

RETEST NO. __ ☐

TEST RESULTS:

THIS VEHICLE HAS BEEN REJECTED WITHOUT TEST BECAUSE:

☐ REQUIRED EMISSION CONTROL DEVICES WERE FOUND TO BE DISCONNECTED OR MISSING. REPAIR OR INSTALLATION OF PROPER DEVICES IS REQUIRED IMMEDIATELY

☐ EXCESSIVE LEAKS IN EXHAUST SYSTEM

☐ EVAPORATIVE EMISSION LOSS COLLECTION SYSTEM

____

REMARKS ______________________________________

____

____

____

INSP. NO.__________ INSP. SIGN.____________________

Figure 8-4. EXAMPLE OF REJECTION SLIP FOR VISUAL INSPECTION

Emission Testing - When it is determined that a vehicle is testable, the emission test would be performed. Measured values would be recorded on the Inspection Report Form, Figure 8-3, and compared to the proper emission standards. Based on this comparison, inspection personnel would make a pass/fail decision. In the case of a failed vehicle, inspection personnel would select proper diagnostic recommendations from the diagnostic chart and record them on the inspection report form. Further diagnostic information derived from visual inspections would also be recorded on the Inspection Report Form.

Certification Forms - When the inspected vehicle's emission levels are less than the established standards, and no repair is required, a Certificate of Compliance would be issued. A copy of the Vehicle Inspection Report would be given to the vehicle owner for his information. This may be of value to his mechanic at the time of his regular maintenance especially for those vehicles that passed marginally.

Failed Vehicles - Should the vehicle fail one or more emission inspection modes, these failures would be denoted by the letter F (for failed) printed after the numeric value, the diagnostic information to be provided would be entered in the Diagnostic Information area. This would be an exception report listing the most probable cause(s) for failure and the measured values for engine parameters used to determine the cause.

The report format would provide a space for remarks to cover unusual problems not covered elsewhere.

Diagnostic Chart - Diagnostic recommendations, selected from the diagnostic chart, and values of key engine parameters would be recorded on the inspection report form. Within the diagnostic chart various parametric criteria would be used to identify the probable cause for high emissions. An abbreviated example of a diagnostic chart is shown in Table 8-5. These charts would be developed by the MVECO and distributed to each test facility upon certification.

Table 8-5. MALFUNCTION TRUTH TABLE

MALFUNCTION	HC		CO		ROUGH IDLE
	High	Very High	High	Very High	
PCV Valve Dirty/Restricted			X		X
Air Cleaner Dirty/Restricted			X	X	
Choke Stuck Partially Closed				X	
Carburetor Idle Circuit Malfunction	X		X		X
Intake Manifold Leak	X	X			X
Ignition Timing Advanced	X				
Leaky Exhaust Valves	X	X			X
Ignition System Misfire	X	X			X

Source: Northrop Study (Ref. 19)

Reports Distribution and Filing - Prior to distributing the inspection reports, the certifying inspector would enter his identification number in the appropriate space and sign the report. He would also stamp the VID card with the facility number and date and return this and the automobile registration card to the owner. After each vehicle's paperwork is completed, Copy 2 would be placed in a basket marked passed or Copy 1 in a basket marked failed. At the end of each day the reports of failed vehicles would be placed in a Retest File in license plate number order. If other failed reports for a given vehicle are already in the file then the motorist should have returned the previous test report and repair summary (Copy 2). Copy 1 of this previous test should be matched to ensure that it is identical to the returned copy, after which Copy 1 can be discarded.

Ultimately there may be one or more failed test reports and repair summaries (Copy 2) and one passed test report (Copy 2) for each vehicle. Periodically, the Retest File would be checked to ensure that failed vehicles have returned for their retest. A query to DMV periodically (perhaps quarterly) by license number, should determine if the vehicle has been subsequently registered, sold, dismantled, abandoned, etc. This action is necessary to purge the files.

For the system to be effective, the failed vehicles must return to the same inspection facility after repair. The method of imprinting facility number and date on the VID card described would provide the necessary control.

Maintenance and Repair Forms - The reverse side of each Vehicle Inspection Report (Copy 2) would be printed with the repair summary form shown in Figure 8-5, and would provide for parts and labor cost information for emission-related repairs. The description of these items would be pre-printed and used as needed. Blank spaces are provided for additional materials or labor actions. Recommended items, as specified by the inspection facility and previously established by the MVD via the diagnostic chart, that were completed by the garage would be so noted. Should additional space be needed, continuation sheets would be used as shown in Figure 8-6. These sheets would be available from the MVD in the form of pads. A fee should be charged for these pads to ensure judicious use.

To ensure that data are not lost, it would be necessary to know when a continuation sheet has been used. Instructions for use would direct the repairing facility to show the total costs only on the continuation sheet (if one is used) and to staple the continuation sheet to the inspection report. Hence, no entry in the total cost blocks on the original repair summary would indicate that a continuation sheet should be attached.

Any other emissions-related work performed that was not recommended by the inspection program should have been voluntarily requested by the vehicle owner and so noted. The costs for required and voluntary work would be identified separately.

Space would be provided for a description and cost estimate of additional emissions-related work which the garage recommends to ensure meeting the emissions standards. In general, this would only be estimates for major engine repairs. However, it is expected that older vehicles would also require these estimates to secure waivers due to cost constraints on repairs. This information would be used when considering issuance of a Certificate of Waiver.

Data Collection for Program Effectiveness Determination - Data would be collected with regard to emissions levels, repair activities and facility operations. Analysis of these data would be performed to ascertain emissions reduction cost-benefit relationships, patterns of malfunctions, the adequacy

MATERIALS USED

REQ	VOL	QUAN	PART NO.	DESCRIPTION	PRICE
				PCV Valve	.
				Air Filter	.
				Spark Plugs	.
				Points	.
				Condenser	.
				Rotor	.
				Wires	.
				Carburetor Overhaul Kit	.
				Replacement Carburetor	.
					.
					.
					.

LABOR ACTIONS

REQ	VOL	DESCRIPTION	LABOR
		Set Dwell	.
		Set Timing	.
		Adjust Idle Mixture/Speed	.
		Set Idle Speed Only	.
		Repair Choke	.
		Repair Heat Riser/Heated Air Inlet	.
		Repair A.I.R. System/Components	.
		Test Compression ( )( )( )( )( )( )( )( )	.
		Overhaul Carburetor	.
		Replace Carburetor ☐ New ☐ Rebuilt	.
		Perform Low Emission Tune-Up	.
			.
			.
			.

Use Continuation Sheet if necessary. Show totals on continuation sheet.

TOTAL VOL LABOR	.
TOTAL VOL PARTS	.
TOTAL REQ LABOR	.
TOTAL REQ PARTS	.
TAX	.
TOTAL	.

DESCRIPTION OF ADDITIONAL RECOMMENDED REPAIRS	ESTIM.
	.
	.
	.
	.
	.

DATE________________________ ODOMETER________________________

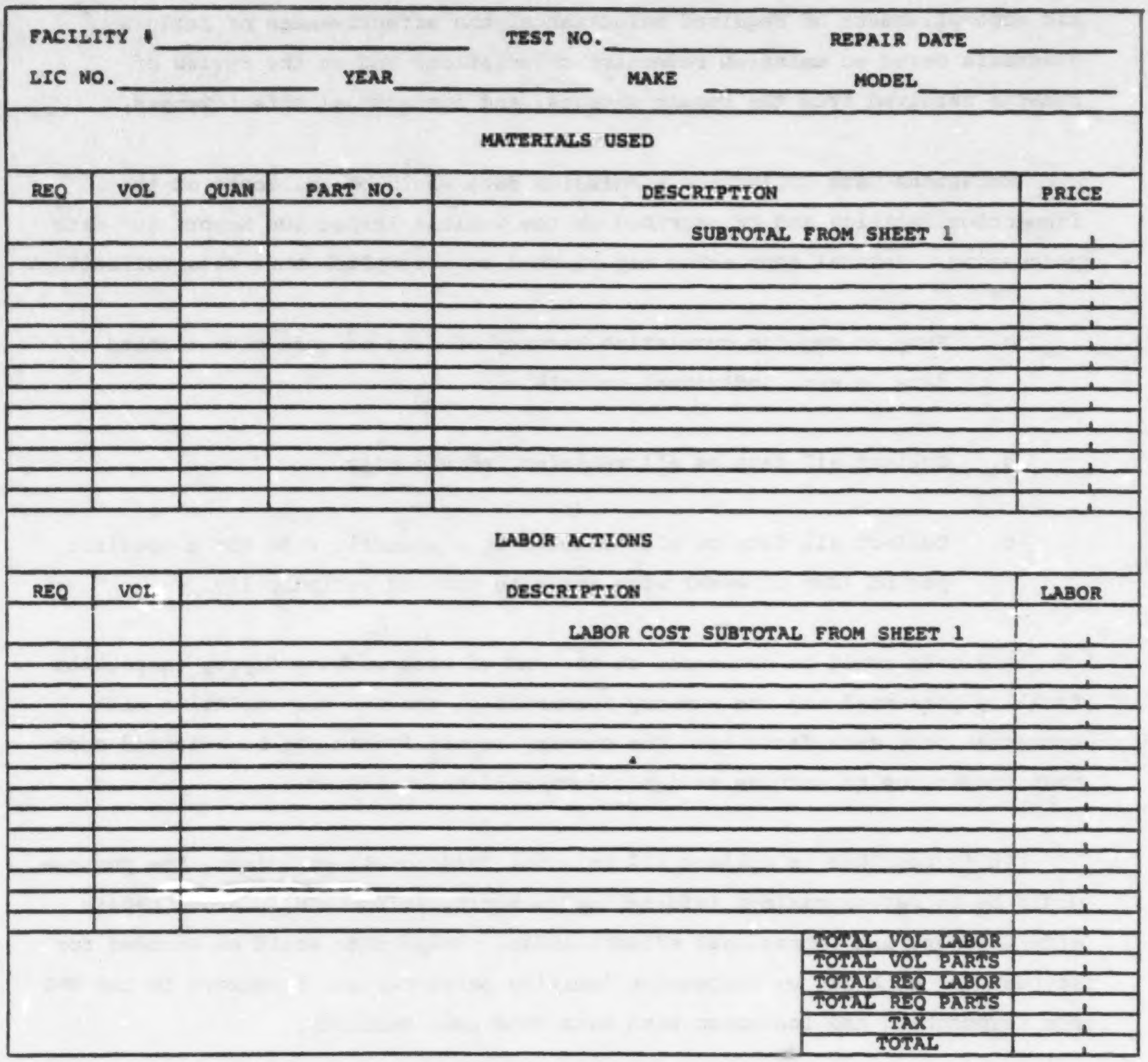
☐ I certify that the recommended maintenance indicated on the reverse side was performed by me or at my request by a mechanic.

Owner
Sign.____________________________

☐ I certify that the recommended maintenance indicated on the reverse side have been performed.

Inst.
Sign.____________________________

Figure 8-5. EMISSIONS CONTROL SYSTEMS REPAIR SUMMARY



FACILITY # ____________ TEST NO. ____________ REPAIR DATE ____________

LIC NO. ____________ YEAR ____________ MAKE ____________ MODEL ____________

MATERIALS USED

REQ	VOL	QUAN	PART NO.	DESCRIPTION	PRICE
				SUBTOTAL FROM SHEET 1	

LABOR ACTIONS

REQ	VOL	DESCRIPTION	LABOR
		LABOR COST SUBTOTAL FROM SHEET 1	

TOTAL VOL LABOR	
TOTAL VOL PARTS	
TOTAL REQ LABOR	
TOTAL REQ PARTS	
TAX	
TOTAL	

Figure 8-6. CONTINUATION SHEET FOR ADDITIONAL REPAIR INFORMATION

and accomplishment of required maintenance, the effectiveness of failure diagnosis based on emission reduction calculations and on the review of remarks received from the repair garages, and operational effectiveness.

Emissions Data Collection - Emission data would be collected at the inspection facility and transcribed on the Vehicle Inspection Report for data processing. Several approaches may be used to accomplish this data collection.

- Keep an ongoing cumulative summary of data at each site instead of data on each individual vehicle.
- Collect all data on all vehicles individually.
- Collect all data on all vehicles at a specific site for a specific period (day or week) with the site changed periodically.

All data could be processed at the end of each working day by inspection facility personnel and the summary forwarded to the MVD for inclusion with summaries from each facility. The summary report format can be arranged such that conversion to machine readable form will be expedited.

It is possible to collect all emission data on all vehicles. The purpose would be to gather maximum information to verify emission standards, repair effectiveness and operational effectiveness. These data would be encoded for keypunching each day by inspection facility personnel and forwarded to the MVD for keypunching and inclusion with data from each facility.

To reduce data handling to a minimum it would be desirable to collect all data for a given period, day or week, from a specified facility. A total sample size of 2,000 vehicles out of 0.94 million should be adequate for the first year (1982) of the program. However, the actual sample size required to ensure statistical significance should be determined by observing the mean and standard deviation of these actual data collected during the first year of the program. To ensure randomness of data collection, an assignment algorithm would be used to indicate where and when the data collection would take place.

If a state or contractor facility were operating at near its projected capacity of 115 tests per lane per day, 1 week of data collection would be perferred to 1 day of data collection.

In the case of a privately-operated facility operating at its projected capacity of less than seven vehicles per day, a statistical design will need to be developed that will allow sufficient data to be collected over a reasonable length of time from an adequate number of stations. Only then can statistically significant statements be made about that particular facility's measure of effectiveness. For the total program, data from all of the sites sampled will be combined for an overall effectiveness measure.

Data Encoding to Machine Readable Form - Data may be transcribed from the printed Vehicle Inspection Report (VIR) onto an 80-column coding sheet which could then be keypunched at the State Data Processing Center for input to a computerized data analysis program. The punched card format shown in Figure 4-11 includes the data for each test on each vehicle. The order of data entry follows the order of listing on the VIR. The data would be encoded as a series of cards after a Certificate of Compliance or Waiver had been issued-- the day of first test for passed vehicles or several days (or weeks) later for failed vehicles. Daily operational information would be tallied separately.

Two problems must be considered for this method of data handling- transcription errors and time expended. Transcription errors cannot be totally eliminated but can be reduced by using a coding form that clearly identifies each data field by title, by using heavy separating lines between fields, by blocking out fields that must be blank, by coding in the same order as data are read, and by fixing decimal points wherever possible. An example of this technique was shown in Figure 8-7.

Time required to fill in these forms and to keypunch the data must be considered. Using a conservative estimate of 50 seconds for manually recording the first test (the only test in the case of passed vehicles), and 40 seconds for each additional test (since descriptive data need only be recorded once), a 35 percent inspection failure rate, a 10 percent reinspection failure rate

Card Cols	Item	Example	Remarks
1-4	Facility number	x111	Constant for each facility
5	Lane number	4	Each test
6	Space		Constant
7-12	License number	123ABC	Each test-for traceability
13-14	Model year	70	Once
15-16	Weight class	x1	in
17-18	Number of cylinders	x8	a
19-20	Emission control code	x3	series
21-23	Odometer (in 1000s)	x42	
24	Space		Constant
25	Test number	1	
26	Test Decision-Failed = 1	blank	
27-30	Idle HC	x150	For
31-35	Idle CO-Fixed Decimal in Col 33	x0.49	each
36-39	Lo Cruise HC	x121	
40-44	Lo Cruise CO-Fixed Decimal in Col 42	x0.38	test
45-48	[illegible]	- -	
49-52	Hi Cruise HC	x123	
53-57	Hi Cruise CO Fixed Decimal in Col 55	x1.01	
58	Space		Constant
59	Required maintenance-Not completed = 1	blank	
60-62	Required Parts Cost - Dollars	xxx	For
63-65	Required Labor Cost - Dollars	xxx	each
66-68	Voluntary Parts Cost - Dollars	xxx	retest
69-71	Voluntary Labor Cost - Dollars	xxx	
72	Space		Constant
73-75	Parts Estimate-Dollars	xxx	For waiver
76-78	Labor Estimate-Dollars	xxx	consideration
79	Space		Constant
80	Waiver-Granted = 1	blank	

NOTE: x is used to show number of available field positions

Figure 8-7. MANUAL DATA ENCODING FORMAT

and 115 tests or retests per lane per day, it would require less than 1.5 hours per lane per day for recording all data manually.

The manual method of data recording applies equally well to the collection of data at a specific site for a specific period.

Repair Cost Data Collection - Cost data on repaired vehicles would be derived from the repair summaries filled out by the repairing facility and returned by the vehicle owner at the time of retest. These data must be transcribed manually to a machine readable form. Assuming 115 tests per lane per day, and an average of 3 minutes per repair summary report, it will require approximately 2.2 hours per day per lane to interpret and code the data.

To provide meaningful cost breakdowns for subsequent data analysis, it will be necessary to identify parts and labor for recommended maintenance separate from voluntary maintenance. This would allow determination of an average cost figure for each of the required maintenance items which can be used in identifying excessive charges. Distinguishing recommended from voluntary maintenance would also aid the consumer by imposing a limitation on the repair garage, and would aid the MVD in identifying repair garages that fraudulently indicate that some voluntary items are required.

An analysis of the repair summary could be made by comparison with a matrix of failure diagnosis versus recommended actions to determine whether:

a. Fewer than the recommended actions were performed.
b. Only the recommended actions were performed.
c. Only recommended and voluntary actions were performed.
d. Excessive actions were performed and indicated as being required.

The result could be encoded along with the given cost data. The Vehicle Repair Summary (Figure 8-5) can be encoded for direct keypunch operation. To facilitate data encoding, the following definitions of correct, excessive, insufficient and incorrect repairs are proposed.

Correct Repairs - A correct repair may be implied if the vehicle passes the retest and the recommended repairs were performed. Additional and voluntary repairs may also be allowed.

Excessive Repairs - The vehicle may pass the retest, but more may have been repaired than was required. It would require considerable test and maintenance data to assure the MVD that only those repairs identified as recommended are sufficient to ensure passing a retest.

Insufficient Repairs - Insufficient repairs would be implied if the vehicle fails the retest. Less than the recommended repairs may have been performed and this can be determined from the repair summary. The recommended repairs may have been completed but the list of repairs or the procedure for a given failure diagnosed may be lacking completeness. It is also possible that more than the recommended repairs were performed and it could still be insufficient since the "correct" diagnosis was not performed.

Incorrect Repairs - If the vehicle fails the retest and fewer than (or none of) the recommended repairs were performed but other repairs were performed, the repair can be considered incorrect. It might also be possible that incorrect repairs were performed due to faulty garage equipment. To identify this possibility, measured engine parameter data should be collected in the early stages of implementation and whenever a vehicle returns to the repair facility after failing a retest. It is possible to have both excessive and incorrect repairs.

Operations Data Collection - There are numerous items of data that would be collected to determine the effectiveness and efficiency of the inspection facilities. These data could include daily tallies of:

- Inspections completed - Pass, Fail, and Fail Retest from VIR copies. Additional breakdowns would be accomplished as part of emissions data analysis.
- Vehicles rejected - Cause, as determined from copies of reject reports.

- Complaints processed - Complaints received, resolved and forms forwarded for investigation.

- System Performance (as determined from system log) - Number of hours in operation, scheduled maintenance - by equipment, unscheduled maintenance - by equipment.

These tallies could be performed during the day following the day of operation being reported on. A sample of an operations worksheet is shown in Figure 8-8. Completion of this log would require approximately 1 hour per day per lane. An additional 45 minutes would be required to collect and organize the data and check it for completeness.

Data Conversion - All cost and operations data would require keypunching from coding sheets. Assuming a total of 3,795 tests per day, keypunching of manually collected emissions data would require approximately 21 hours per day (at 160 to 200 cards per hour). This punching could be done at the State Data Processing Center or by a service bureau.

8.5 LEGISLATIVE CONSIDERATIONS

In designing an I/M program, there must be careful consideration of potential problem areas that could hinder acceptance by the State Legislature. These potential problem areas are the result of secondary impacts that may be unforeseen by program designers. These secondary impacts include political constraints, socioeconomic considerations, and institutional effects. These impacts are wide in scope, illustrating the pervasive effects of I/M on the population. Among the more important secondary impacts, the following require early legislative consideration:

- Impact on those groups that must subsist on low or fixed yearly income (e.g.; the poor, the disabled, and the elderly).

<table>
<tr><th></th><th colspan="2">Date</th><th colspan="2">Date</th><th colspan="2">Date</th><th colspan="2">Date</th><th colspan="2">Date</th><th colspan="2">Date</th><th colspan="2">Week Total</th></tr>
<tr><td>Inspections Completed</td><td colspan="2"></td><td colspan="2"></td><td colspan="2"></td><td colspan="2"></td><td colspan="2"></td><td colspan="2"></td><td colspan="2"></td></tr>
<tr><td>Pass</td><td colspan="2"></td><td colspan="2"></td><td colspan="2"></td><td colspan="2"></td><td colspan="2"></td><td colspan="2"></td><td colspan="2"></td></tr>
<tr><td>C of Cs Issued</td><td colspan="2"></td><td colspan="2"></td><td colspan="2"></td><td colspan="2"></td><td colspan="2"></td><td colspan="2"></td><td colspan="2"></td></tr>
<tr><td>Initial Failure</td><td colspan="2"></td><td colspan="2"></td><td colspan="2"></td><td colspan="2"></td><td colspan="2"></td><td colspan="2"></td><td colspan="2"></td></tr>
<tr><td>Failed Retest 1</td><td colspan="2"></td><td colspan="2"></td><td colspan="2"></td><td colspan="2"></td><td colspan="2"></td><td colspan="2"></td><td colspan="2"></td></tr>
<tr><td>Failed Retest 2</td><td colspan="2"></td><td colspan="2"></td><td colspan="2"></td><td colspan="2"></td><td colspan="2"></td><td colspan="2"></td><td colspan="2"></td></tr>
<tr><td>Waivers Issued</td><td colspan="2"></td><td colspan="2"></td><td colspan="2"></td><td colspan="2"></td><td colspan="2"></td><td colspan="2"></td><td colspan="2"></td></tr>
<tr><td>Vehicles Rejected</td><td colspan="2"></td><td colspan="2"></td><td colspan="2"></td><td colspan="2"></td><td colspan="2"></td><td colspan="2"></td><td colspan="2"></td></tr>
<tr><td>Retrofit Lacking</td><td colspan="2"></td><td colspan="2"></td><td colspan="2"></td><td colspan="2"></td><td colspan="2"></td><td colspan="2"></td><td colspan="2"></td></tr>
<tr><td>Control System Inoperative</td><td colspan="2"></td><td colspan="2"></td><td colspan="2"></td><td colspan="2"></td><td colspan="2"></td><td colspan="2"></td><td colspan="2"></td></tr>
<tr><td>Brakes</td><td colspan="2"></td><td colspan="2"></td><td colspan="2"></td><td colspan="2"></td><td colspan="2"></td><td colspan="2"></td><td colspan="2"></td></tr>
<tr><td>Exhaust Leaks</td><td colspan="2"></td><td colspan="2"></td><td colspan="2"></td><td colspan="2"></td><td colspan="2"></td><td colspan="2"></td><td colspan="2"></td></tr>
<tr><td>Fluid Leaks</td><td colspan="2"></td><td colspan="2"></td><td colspan="2"></td><td colspan="2"></td><td colspan="2"></td><td colspan="2"></td><td colspan="2"></td></tr>
<tr><td>Complaints Processed</td><td colspan="2"></td><td colspan="2"></td><td colspan="2"></td><td colspan="2"></td><td colspan="2"></td><td colspan="2"></td><td colspan="2"></td></tr>
<tr><td>Received</td><td colspan="2"></td><td colspan="2"></td><td colspan="2"></td><td colspan="2"></td><td colspan="2"></td><td colspan="2"></td><td colspan="2"></td></tr>
<tr><td>Resolved</td><td colspan="2"></td><td colspan="2"></td><td colspan="2"></td><td colspan="2"></td><td colspan="2"></td><td colspan="2"></td><td colspan="2"></td></tr>
<tr><td>Forwarded</td><td colspan="2"></td><td colspan="2"></td><td colspan="2"></td><td colspan="2"></td><td colspan="2"></td><td colspan="2"></td><td colspan="2"></td></tr>
<tr><td>Hours of Operation</td><td colspan="2"></td><td colspan="2"></td><td colspan="2"></td><td colspan="2"></td><td colspan="2"></td><td colspan="2"></td><td colspan="2"></td></tr>
<tr><td>Lane 1</td><td colspan="2"></td><td colspan="2"></td><td colspan="2"></td><td colspan="2"></td><td colspan="2"></td><td colspan="2"></td><td colspan="2"></td></tr>
<tr><td>Lane 2</td><td colspan="2"></td><td colspan="2"></td><td colspan="2"></td><td colspan="2"></td><td colspan="2"></td><td colspan="2"></td><td colspan="2"></td></tr>
<tr><td>Lane 3</td><td colspan="2"></td><td colspan="2"></td><td colspan="2"></td><td colspan="2"></td><td colspan="2"></td><td colspan="2"></td><td colspan="2"></td></tr>
<tr><td>Lane 4</td><td colspan="2"></td><td colspan="2"></td><td colspan="2"></td><td colspan="2"></td><td colspan="2"></td><td colspan="2"></td><td colspan="2"></td></tr>
<tr><td>Maintenance Hours</td><td>Sched</td><td>Unsched</td><td>Sched</td><td>Unsched</td><td>Sched</td><td>Unsched</td><td>Sched</td><td>Unsched</td><td>Sched</td><td>Unsched</td><td>Sched</td><td>Unsched</td><td>Sched</td><td>Unsched</td></tr>
<tr><td>Lane 1</td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td>Equipment A</td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td>Equipment Z</td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td>Lane 4</td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td>Equipment A</td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td>Equipment Z</td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
</table>

Figure 8-8. EXAMPLE OF DAILY OPERATIONS SUMMARY WORKSHEET

- Impact on the repair industry.

- Consumer protection.

8.5.1 Impact on Low-Income Groups

A major concern posed by consumer protection groups, legal aid societies, etc., involves the effect of I/M on low-income groups. It is felt that since older vehicles as a group are more likely to be seriously out of compliance with emission standards, the maintenance cost would be prohibitive and, in effect, deny low-income citizens the right to operate older vehicles.

This problem can be remedied by establishing exemption criteria for certain vehicles requiring costly emission-related work to be performed. One criterion involves a repair cost ceiling based on an absolute dollar figure, or the percentage of vehicle value--whichever is lowest. The second criterion would exempt vehicles of a certain age (e.g.; pre-1952, antique vehicles). Both criteria would substantially reduce the cost burden on low-income groups.

These exemptions would not have a significant effect on the I/M program effectiveness on reducing emissions from the in-use vehicle population. The majority of vehicles that are seriously out of compliance with established emission standards tend to be older (5 years), and probably would not remain in the vehicle population much longer. Resale vehicles that filter down over time to replace the gross emitters would have been maintained as a result of I/M and should not be as costly to keep in compliance.

A potential problem area requiring legislative resolution involves the question of warranty protection. Presently, emission devices are subject to a 50,000 mile/5-year manufacturer's warranty. In most cases, the warranties on older vehicles owned by low-income groups have expired. This places a burden on low-income groups that are required to replace costly emission control devices. It should be mentioned that it is unknown how long these durable devices will last and may conceivably remain operative until the end of the vehicle's useful life.

8.5.2 Impact on the Repair Industry

The repair industry has considerable lobbying power that may be exerted on the legislature. Areas of special concern involve questions of how I/M will affect the ability of the repair industry to maintain vehicles; the accuracy of the HC/CO analyzer; the ability to profitably finance program equipment; and, finally, new rules, regulations, and restrictions that may be placed on the repair industry. These questions can certainly be voiced and perhaps resolved through committees and public hearings.

8.5.3 Consumer Protection

Legislative provisions must be made to ensure that vehicle owners are protected from abuses that could appear in the maintenance phase of an I/M program (e.g.; overcharging, unnecessary repairs, and warranty protection). Section 7.2 provided descriptions of various program issues that should be adequately covered by initial legislation. As program development advances, it is likely that other issues will surface requiring revision or modification of initial legislation.

8.5.4 Legislative Implementation

The first stage in the implementation of an I/M program is the development of appropriate enabling legislation. For the drafting of the enabling legislation, a preliminary description of the major program components should be prepared and the organizational option should be decided upon. Program objectives, operating rules, program scope and major agency responsibilities should be specified. Planning and trade-off studies will result in the identification of the technical, social, and economic characteristics of the desired I/M program. This aids in the structuring of the legislation.

Several states have already passed legislation establishing legal requirements for the control of emissions of HC, CO, and NO_x from motor vehicles. In some cases, this has been accomplished by either an act of the State Legislature, or through official action taken by an air pollution control board, commission, or other state agency. Either method is acceptable, depending on the legal requirement of individual states, so long as a firm legal authority is established under which necessary action can be taken.

Generally, most of these laws and regulations include two provisions. The first is a legal requirement that the owner or operator of a motor vehicle should not deliberately remove or inactivate the emission control devices presently required of automobile manufacturers.

The second provision establishes a system of inspection and/or maintenance programs. This provision would address specific issues (i.e.; legal authority, fees, penalties), that should be incorporated into the enabling legislation such as:

- Adequate authority to adopt rules and regulations concerning:
    - requirements for periodic inspection
    - establishment of fees for providing the inspection service
    - withholding vehicle registration for those vehicles that do not satisfactorily complete the inspection or that do not comply with an applicable emission variance
    - prohibition of tampering
    - vehicle exemption.
- Provisions for providing adequate funds for implementing, monitoring, and enforcing the I/M program.
- Adequate authority to obtain pertinent data and information, and require periodic reporting of emission information.
- Authority to develop emission reports and information suitable for public inspections.

- Authority to compel compliance with rules and regulations, supported by civil or criminal penalties.

- Provisions for injunctive relief where deemed necessary.

- Provisions for public hearings.

8.6 MECHANICS TRAINING

A high level of skill and technical competency of automotive mechanics is required to repair, diagnose, and adjust vehicles to emission standard levels. This implies that mechanics must be thoroughly familiar with the underlying principles, theory, and operation of emission control devices. However, this becomes increasingly difficult owing to the great diversity of vehicles, profusion of various makes/models/years, and their associated emission devices. This problem becomes compounded by the fact that emission control technology is becoming increasingly more complex. The end result is an apparent shortage of qualified mechanics capable of correctly diagnosing engine parameters.

In order to ensure that enough qualified mechanics are available to service and repair vehicles according to I/M specifications, present educational programs should be upgraded to meet the current and future needs of the repair industry. This may be accomplished, prior to implementation of I/M, if the State takes an active role in formulating criteria that evaluate, train, and assist currently employed mechanics. These criteria would include:

- Mechanic training curricula which incorporate multimedia aids that review step-by-step emission tune-up techniques.

- Assessment of mechanic qualification requirements, and development of qualification examinations.

- Conducting pilot programs to evaluate the effectiveness of training programs.

Each criterion will be covered in greater detail in the following subsections.

8.6.1 Mechanic Curricula

There is a wide variety of mechanic training programs currently available at the various trade, vocational, and technical schools. These programs will differ in content because of the different degree requirements of each school. Unfortunately, many of these programs either ignore or superficially cover the effects of various engine parameters on vehicle emissions. This problem can be remedied if a standardized and comprehensive emission control training program is instituted at selected schools.

As part of this comprehensive training program, an EPA-approved emissions control course would become mandatory. Colorado State University has recently published a "Motor Vehicle Emissions Control Instructional Materials Packet" that has been extensively field tested and widely accepted by many states. This packet is designed to be used by vocational automotive instructors as a complete multimedia approach to emissions control systems. The topics that are covered in-depth include: positive crankcase ventilation, thermostatic air cleaner, air injection reaction, fuel evaporation, exhaust gas recirculation, spark control, and catalytic converters.

Once the fundamentals of emission controls are covered in sufficient detail, supplemental courses (Table 8-6) could be made available to emission inspectors and repair mechanics alike. These courses would add greatly to the mechanics understanding of the needs, concepts, and requirements of an I/M program.

An important by-product of a mechanic training program would be the development of a handbook that describes definite repair sequences for each type of emission failure. Mechanics would be instructed to proceed only so far as the step that corrects the particular malfunction. This would alleviate unnecessary repair work.

TABLE 8-6. CONTENT OF TRAINING COURSES

COURSE TITLE	COURSE HOURS	SUBJECTS	EQUIPMENT AND DOCUMENTS
Program Orientation	1-2	Objectives of and general procedures used in periodic inspection and maintenance. Program structure including organization charts, and relationships to other State and local agencies. Relationship of PVI to other air pollution control strategies. Data flow within agency and between related agencies. Enforcement procedures for vehicle owners and repair facilities. Consumer information and protection measures.	Slide/tape or sound movie presentation including pictorial and diagramatic visual aids. Question and answer period follows. Distribute Consumer's Handbook.
Vehicle Emissions and Standards	7-8	General discussion of mechanisms producing hydrocarbon, carbon monoxide, nitric oxide and smoke (particulates) emissions. Concepts of normal emission levels and excess emission levels. Effect of factors such as misfire, air/fuel ratios, and combustion temperature on emission levels. Emission standards and regulations mandating particular OEM or retrofit equipment. General types of emission control systems, including general configuration, theory of operation and typical effect on emission levels at different engine operating conditions. Identify differences in standards set for emission inspection and original manufacturer certification. Identify distinction between Federal and State standards and equipment configurations by model year.	Film or videotape presentation including pictorial and diagramatic visual aids. Distribute training manual on emission controls and standards.
Inspection Procedures	21-24 (1st day)	Facility layout. Description, purpose and use of principal equipment. Facility personnel organization, shifts, duties, and authority of each inspector. Vehicle traffic flow through facility. Public relations and manner of dealing with the motorist.	Film or videotape presentation showing actual facility and equipment configuration. Provide training manual to trainees.

(continued)

TABLE 8-6. (continued)

COURSE TITLE	COURSE HOURS	SUBJECTS	EQUIPMENT AND DOCUMENTS
	(2nd day)	Specific inspection procedures for each work station. Procedures for visual inspection. Specific vehicle emission control equipment configurations by model year. Exemptions. Retrofit requirements. Examples of equipment violations. Procedures for connecting ignition analyzer and exhaust probe. Emission inspection driving pattern. Interpretation of test results. Consulting with driver on vehicle results. Grounds for waiver.	
	(3rd day)	Laboratory practice in facility or lane mock-up. Each inspector performs at each work station for 1 hour performing inspections on sample vehicles. Emphasize order of tasks, completeness of visual inspection, accuracy of driving inspection test, interpretation of results, dealing with the public. Set-up and calibration of equipment. Start-up and shutdown of facility. Certification of inspection personnel and assignment to facility.	Inspection lane, either in facility or mock-up at training center. Duplication of equipment used in actual facility.
Repair Procedures	4	Ignition and carburetor systems. Emission control systems. Diagnosis of engine malfunctions using scope and and infrared analyzers. The service warranty and criteria for satisfactory performance. Completing, signing, and returning repair forms and estimates, information required, and method of entering data.	Film or videotape of vehicles being tested and repaired for typical malfunctions. Issue mechanics a certificate and note attendance. Distribute Repair Procedures Manual.
Fleet-Owner Inspection and Maintenance	7-8	Describe the emission test. Show typical test bay with gas analyzers. Describe data recorded. Explain various emission standards. Calibration and use of gas analyzers. Diagnosis of failures using emission data. Use of ignition scope in diagnosing HC failures. Reporting of information and retention of records. Spot surveillance of vehicles and test facility. Cost savings of inspection for directing vehicle maintenance activity.	Film or videotape of inspection process and emissions-related repairs. Training manual defining procedures and guidelines.

(continued)

TABLE 8-6. (continued)

COURSE TITLE	COURSE HOURS	SUBJECTS	EQUIPMENT AND DOCUMENTS
Administrative Procedures	3-4	Specific procedures for recording, transmitting, and reporting test data and requisitioning supplies and services. Administrative, personnel, budgetary, and public relation policies and procedures. Management procedures.	Training manual and film or videotape presentation

8.6.2 Mechanic Qualification/Certification

Before state-approval is given to perform emission repair work, a mechanic should be required to demonstrate proficiency by:

- Successfully completing the required number of training courses.
- Correctly diagnosing and repairing control vehicles to meet emission requirements.
- Passing qualification examinations designed to test the mechanic's understanding of the principles and theory underlying emission control devices.
- Demonstrating a working knowledge of Federal and State laws and regulations governing emission control.

Upon the successful completion of the above requirements, the mechanic would be certified.

8.7 INSPECTION STATION FACILITIES

An I/M program with centralized inspection system utilizes high-volume output inspection lanes. To economize program costs, stations with multiple lanes may be considered. However, increase in number of lanes per station will reduce total number of stations required. Thus, reduce consumer convenience.

The number of lanes per station and their sensitivity factors were presented in Tables 2-19 through 2-23. The major variations are those costs that are sensitive to a number of stations and station size.

For decentralized inspection system, number of test stations is in general determined by the market behavior of auto service industry.

8.8 PROGRAM FUNDING

Costs associated with an I/M program can be, in general, appropriated through the following mechanisms:

- o General State funds
- o Fee change collected at the time of emission inspection
- o Registration fee

Other possibilities are through gasoline tax or Federal grant. For centralized system (state- or contractor-operated), initial capital investment may be financed through borrowing from the public. This can be done by issuing tax-exempted low interest bond. Such an arrangement can partially shift the burden of financing the capital investment for I/M from the State to the Federal government.

The financing for decentralized system (private garage-operated) normally goes through loan from private financial institutions. However, private garages may write off their capital expenditure through tax deductions. This gives the same advantage of shifting partial burden of financing to the Federal government as centralized systems (state or contractor) do.

The introductory phase of an I/M program will likely get support from funds by the Clean Air Act, Section 105. However, it will be the State's responsibility to have a self-supported I/M program in the mandatory phase.

8.9 INSPECTION FREQUENCY

To determine inspection frequency, cost-effectiveness of inspection frequency as related to potential emission reduction must be considered. Experience has indicated that annual inspection of normally used vehicles (e.g., passenger cars) is preferrable.

Annual inspection is justified on the basis that it minimizes costs and maximizes public acceptance while maintaining a reasonable high level of emission reduction. A semi-annual program would involve substantially higher program costs arising from the need for a greater number of inspection lanes, as compared to an annual inspection program. A bi-annual program, while certainly providing some emission benefits, will lose some of the effectiveness of an annual program because cars are allowed to deteriorate to a higher level. (Ref. 17.)

High-use vehicles, such as taxis, company cars and trucks, generate more mileage than regular passenger cars. Thus, a single high-use vehicle may produce more emissions yearly than a normal-use vehicle, if it is not properly maintained. It would be desirable to require that these vehicles be inspected more frequently.

Section 9

I/M PROGRAM IMPLEMENTATION SCHEDULE

9.1 USEPA REQUIREMENTS

In the statement of I/M policy, USEPA requires that implementation of an I/M program should be "as expeditiously as practicable". Implementation of mandatory repair for failed vehicles shall begin no later than two and a half years after passage of needed legislation or certification of adequate legal authority for new centralized systems. A shorter period of one and a half years is allowed after legislation or certification for decentralized systems or for centralized systems which are adding emission inspections to safety inspections.

> "For the normal legislation deadline of June 30, 1979, new centralized program must start by December 31, 1981, and all others must start by December 31, 1982, while all other programs must start by December 31, 1981. Where I/M can be implemented more expeditiously, it must be. Each state implementation schedule must be looked at individually to determine if it is as expeditious as practicable. Implementation dates ordered by courts, if earlier than these dates, take precedence" (Ref. 53).

The policy further identifies specific items to be included as a part of the state's I/M implementation schedules. These items are:

"1. Initiation (or continuation) of public information program including publicizing the I/M program in the media, meeting and speaking with affected interest groups, etc.

2. Preparation of a draft legislative package and submittal of legislation package to legislature if additional legislative authority is needed.

3. Certification of adequate legal authority by appropriate state official.

4. Initial notification of garages explaining program and schedule of implementation.*

Preceding page blank

5. Development and issuance of RFPs.*

6. Award to contractor(s).*

7. Initiation of construction of facilities.*

8. Completion of construction of facilities.*

9. Adoption of procedures and guidelines for testing and quality control including emission analyzer requirements (and licensing requirements for private garages, if applicable*).

10. Notification of and explanation to garages of actions in step 9.*

11. Completion of equipment purchase and delivery of equipment.

12. Development and adoption of cutpoints.

13. Initiation of hiring and training of inspectors or licensing of garages.*

14. Initiation of introductory program (voluntary maintenance with either voluntary or mandatory inspection) if not previously initiated.

15. Initiation of mechanics training and/or information program.

16. Initiation of mandatory inspection.

17. Initiation of mandatory repair for failed vehicles.

"If certification of adequate legal authority occurs after January 1979, the States may modify previous commitments to implement and enforce the elements of the schedule to conform to the legal authority.** These modifications will be approved by the EPA Regional Offices and must be consistent with the Administrator's February 24, 1978, policy memorandum. The documents should be submitted to the EPA Regional Offices for inclusion in the SIP revisions already submitted by January 1, 1979. Any necessary adjustments to the schedule may be made at this time but must be approved by the EPA Regional Offices.

"*Dependent on type of system chosen (state-run centralized, contractor centralized, or decentralized).

"**Sections 172(b)(7) and (10) provide that the plan revisions required for nonattainment areas shall --

(7) identify and commit the financial and manpower resources necessary to carry out the plan provisions required by this subsection; (Emphasis added) and shall --

(10) include written evidence that the state, the general purpose local government or governments, or a regional agency designated by general purpose local governments for such purpose, have adopted by statute, regulation, ordinance, or other legally enforceable document, the necessary requirements and schedule and timetables for compliance, and are committed to implement and enforce the appropriate elements of the plan; (Emphasis added)."

9.2 IMPLEMENTATION SCHEDULE

Based on USEPA requirements, different implementation schedules were developed according to the classification of administrative options, i.e., state-operated, contractor-operated, and private garage-operated.

The implementation schedule is separated into three stages: 1) general phasing functions, 2) development activity, and 3) test center operation. The timing of the elements indicated may be revised by the State to reflect other factors and constraints which are beyond the scope of this study.

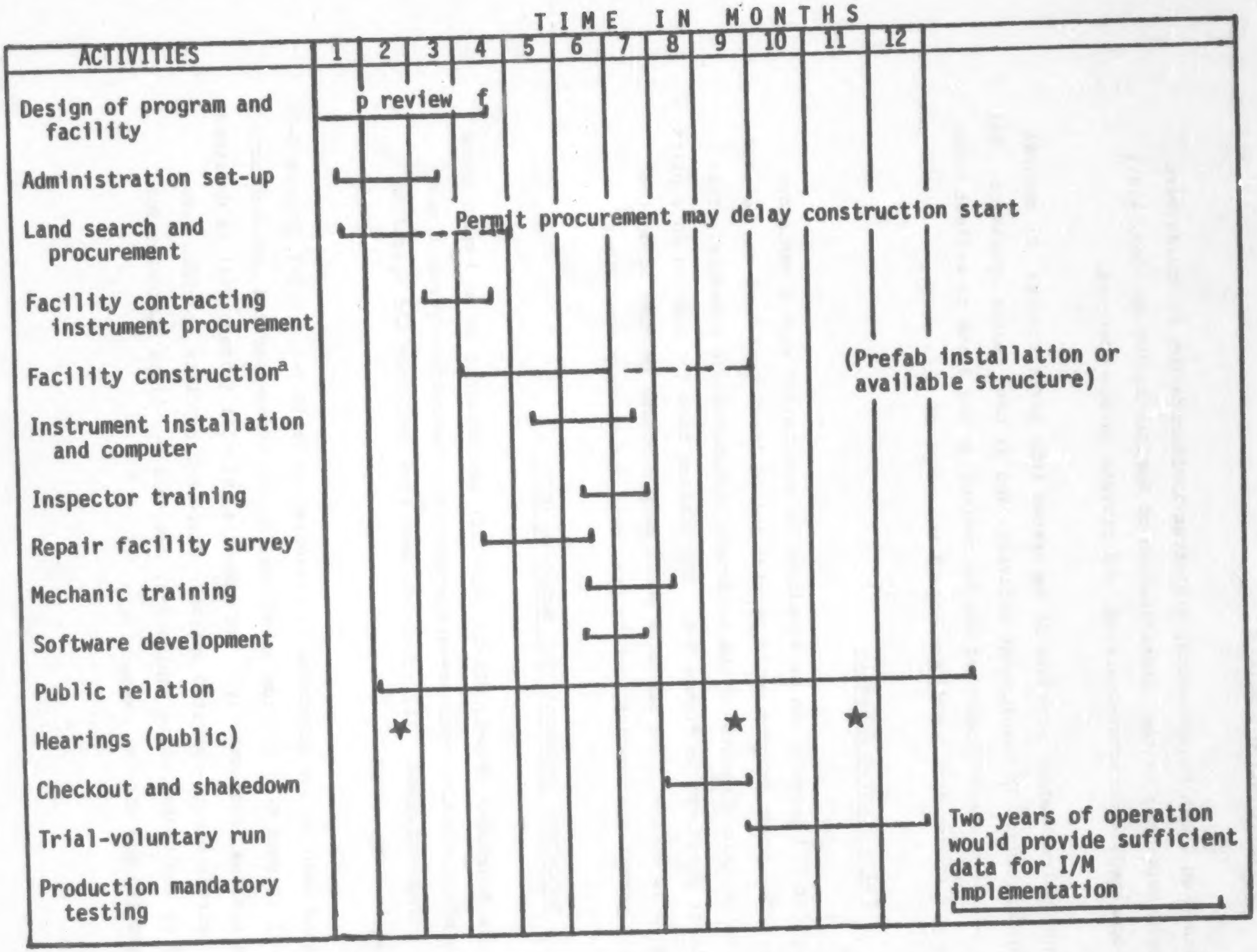
9.2.1 Pilot Program Schedule

A pilot I/M program can be scheduled in association with a mandatory program. The pilot program would provide actual local data that can be used to revise certain elements of the mandatory implementation schedule. This schedule is presented in Figure 9-1. The minimum time for phasing in a pilot program is 12 months. The schedule could slip 6 months because of design problems, permit procurement, public hearings, and weather conditions.

9.2.2 Mandatory Implementation Schedule (MIS)

Three schedules (MIS-I, MIS-II, MIS-III) are designed to implement three possible administrative options--state-operated, contractor-operated, and private garage-operated. All schedules meet time deadlines and specified items required by. USEPA.

Legend used in the schedules is presented in Table 9-1. MIS-I (Figure 9-2) and MIS-II (Figure 9-3) provide schedules for the state-operated and contractor-operated options, respectively. The scheudle, MIS-III (Figure 9-4) is designed for the private garage-operated option. Table 9-2 reprints specific terms required by the USEPA, while Tables 9-3, 9-4, and 9-5 lists footnotes for MIS-I, MIS-II, and MIS-IV, respectively.



[a] All phases are subject to construction delays because of zoning, building permit and inspection.

Figure 9-1. PILOT PROGRAM TIMELINE

Table 9-1. LEGEND USED IN THE MANDATORY IMPLEMENTATION SCHEDULES

△	ACTIVITY STARTS
▽	ACTIVITY ENDS
◇	DECISION POINT
□	REQUIRED ITEMS BY USEPA (WITH NUMERIC LISTING, SEE TABLE 9-2)
○	FOOTNOTES (WITH ALPHABETIC LISTING, SEE TABLES 9-3, 9-4, and 9-5)

Figure 9-2

I/M PROGRAM IMPLEMENTATION SCHEDULE
FOR THE STATE OPERATED FACILITIES
Sheet 1 of 3

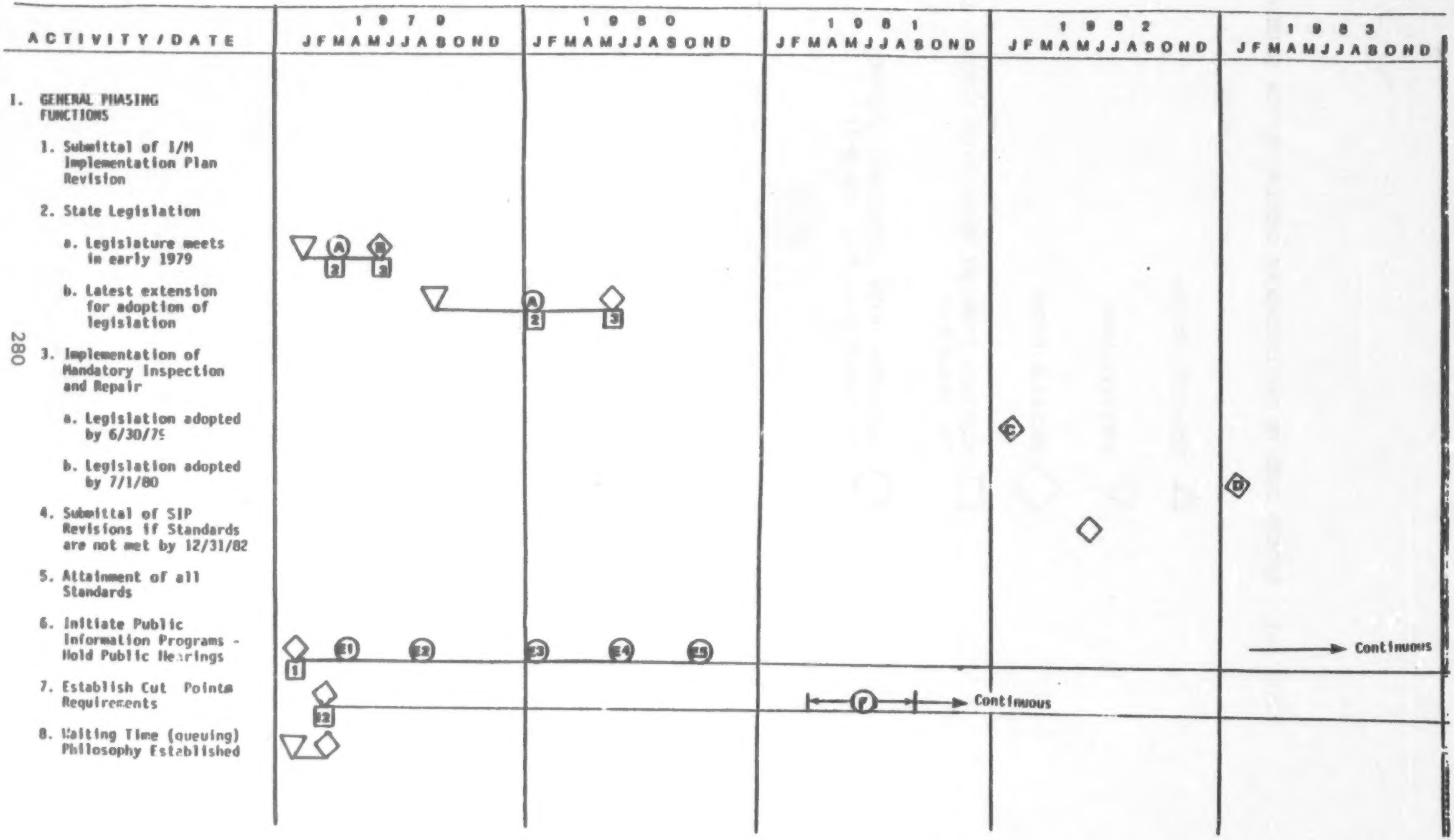


Figure 9-2

I/M PROGRAM IMPLEMENTATION SCHEDULE
FOR THE STATE-OPERATED FACILITIES
Sheet 2 of 3

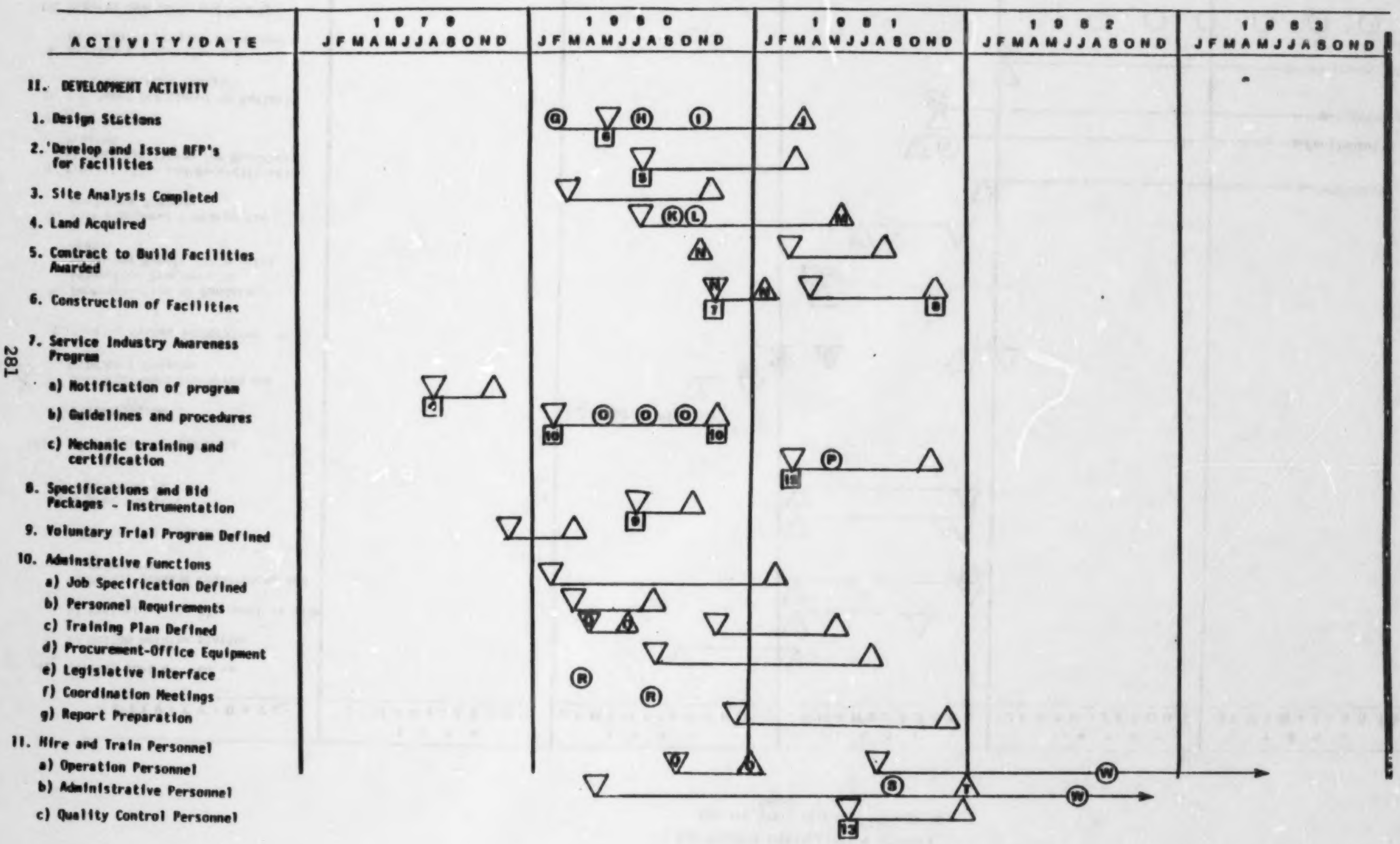


Figure 9-2

I/M PROGRAM IMPLEMENTATION SCHEDULE
FOR THE STATE OPERATED FACILITIES
Sheet 3 of 3

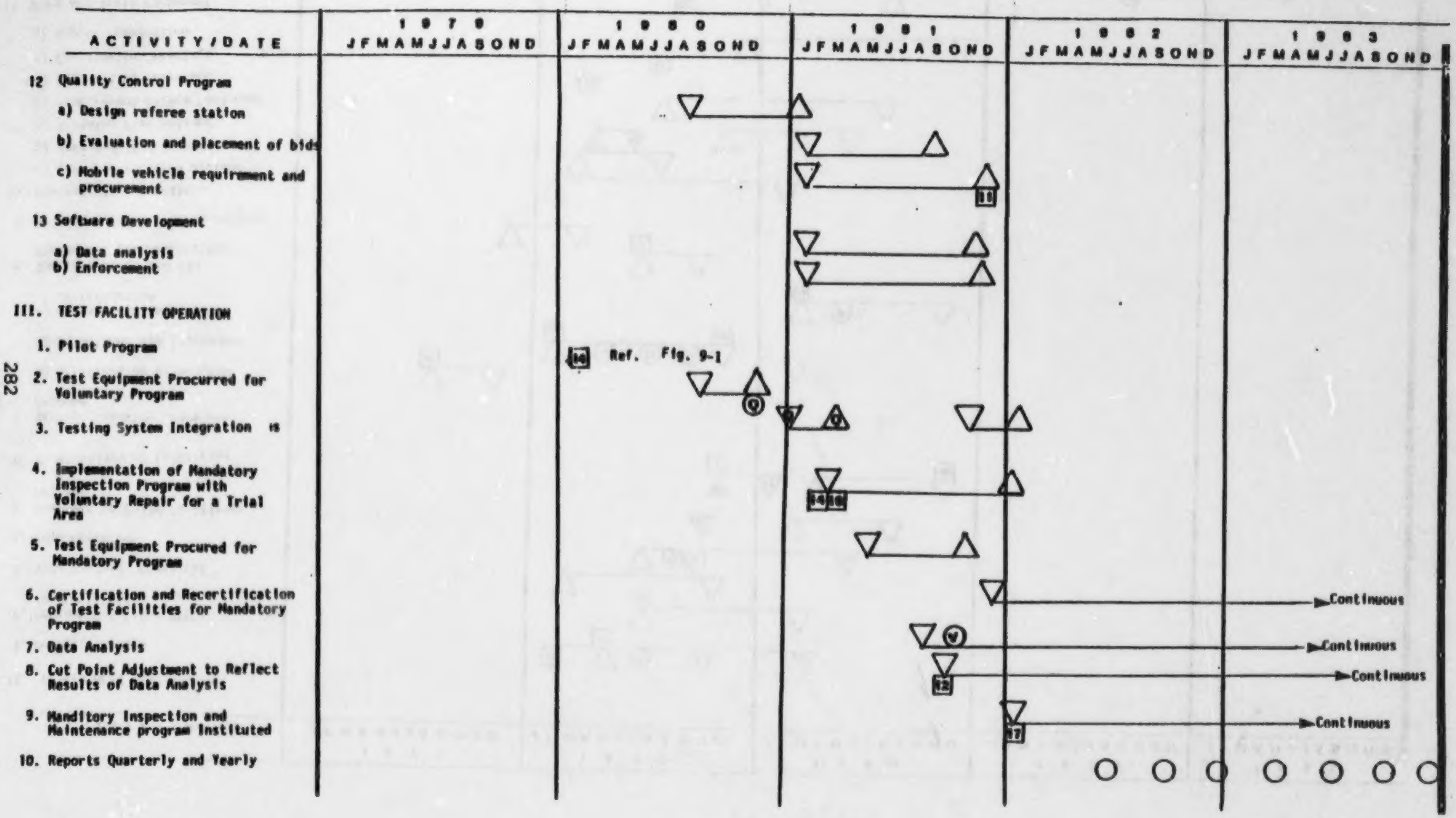


Figure 9-3

I/M PROGRAM IMPLEMENTATION SCHEDULE
FOR THE CONTRACTER OPERATED FACILITIES
Sheet 1 of 5

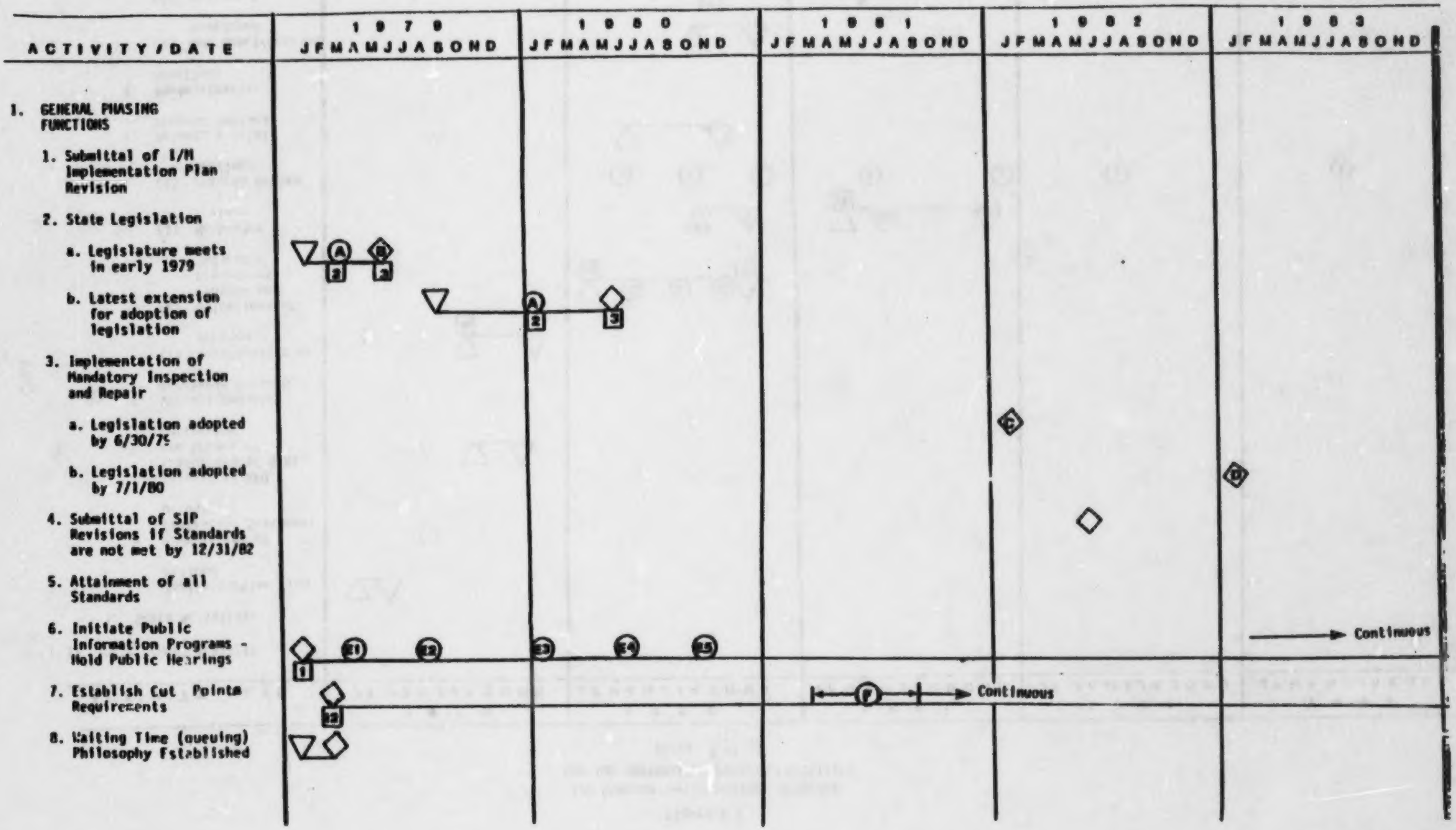


Figure 9-3

I/M PROGRAM IMPLEMENTATION SCHEDULE
FOR THE CONTRACTOR OPERATED FACILITIES
Sheet 2 of 5

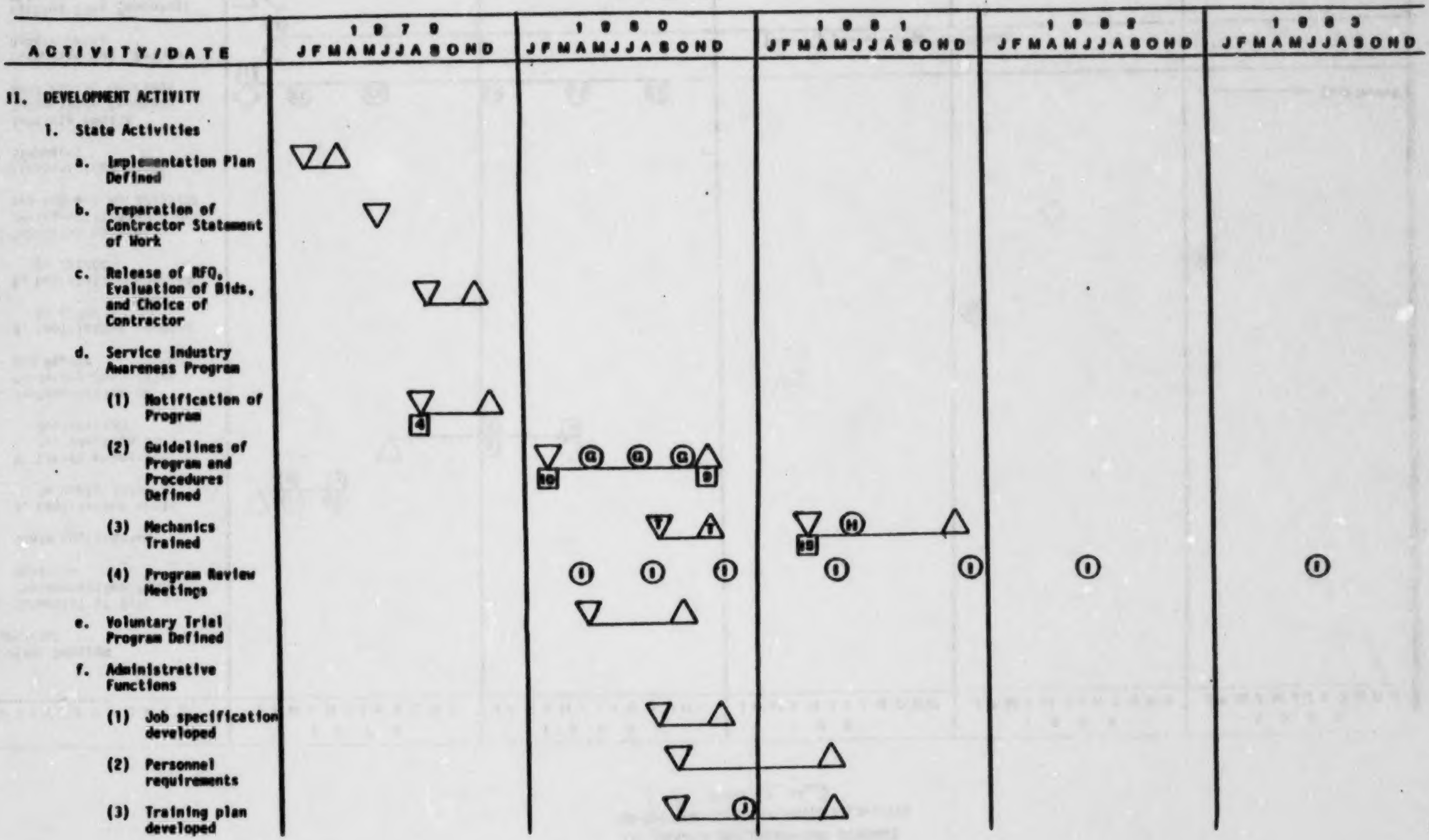


Figure 9-3

I/M PROGRAM IMPLEMENTATION SCHEDULE
FOR THE CONTRACTOR OPERATED FACILITIES
Sheet 3 of 5

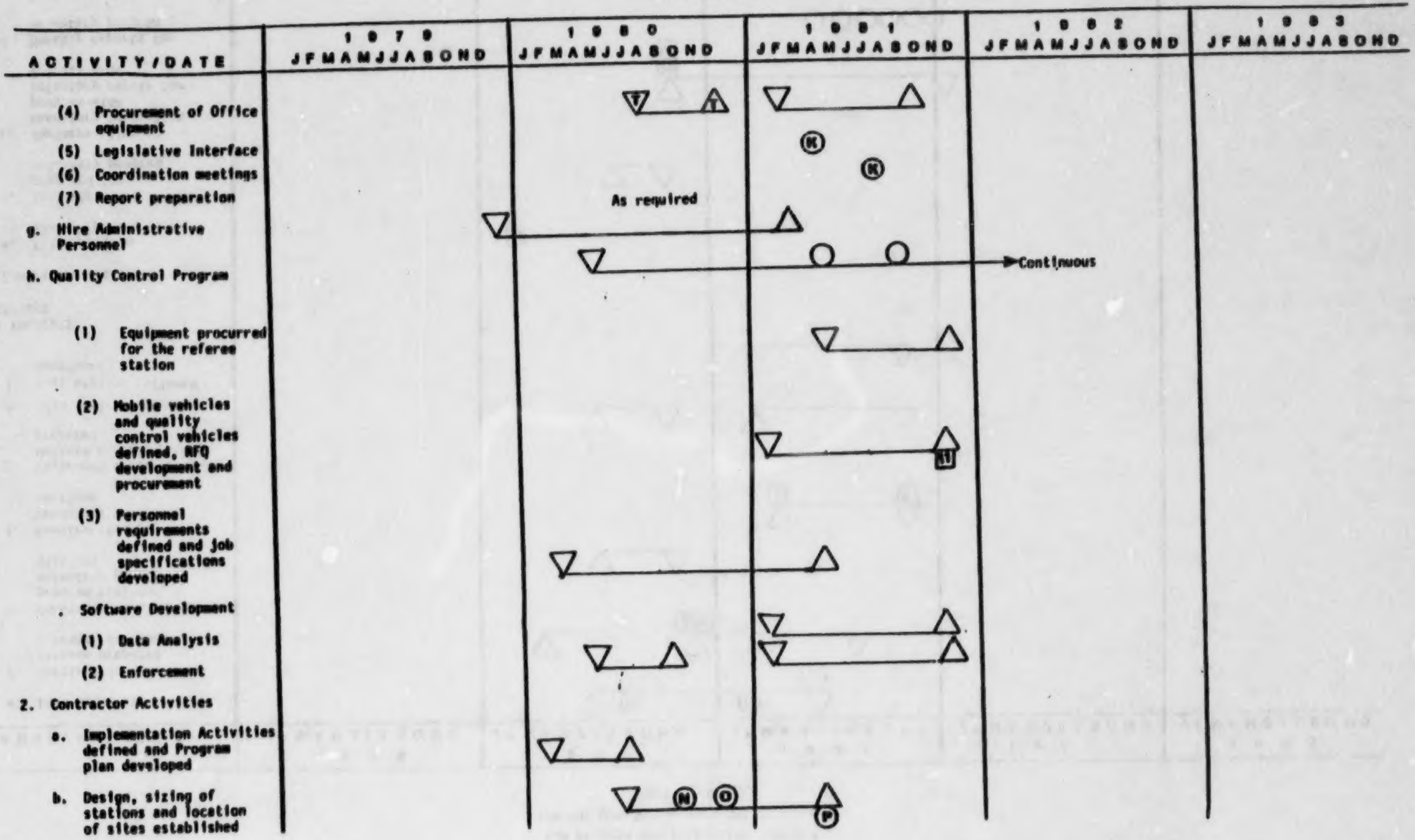


Figure 9-3

I/M PROGRAM IMPLEMENTATION SCHEDULE
FOR THE CONTRACTOR OPERATED FACILITIES
Sheet 4 of 5

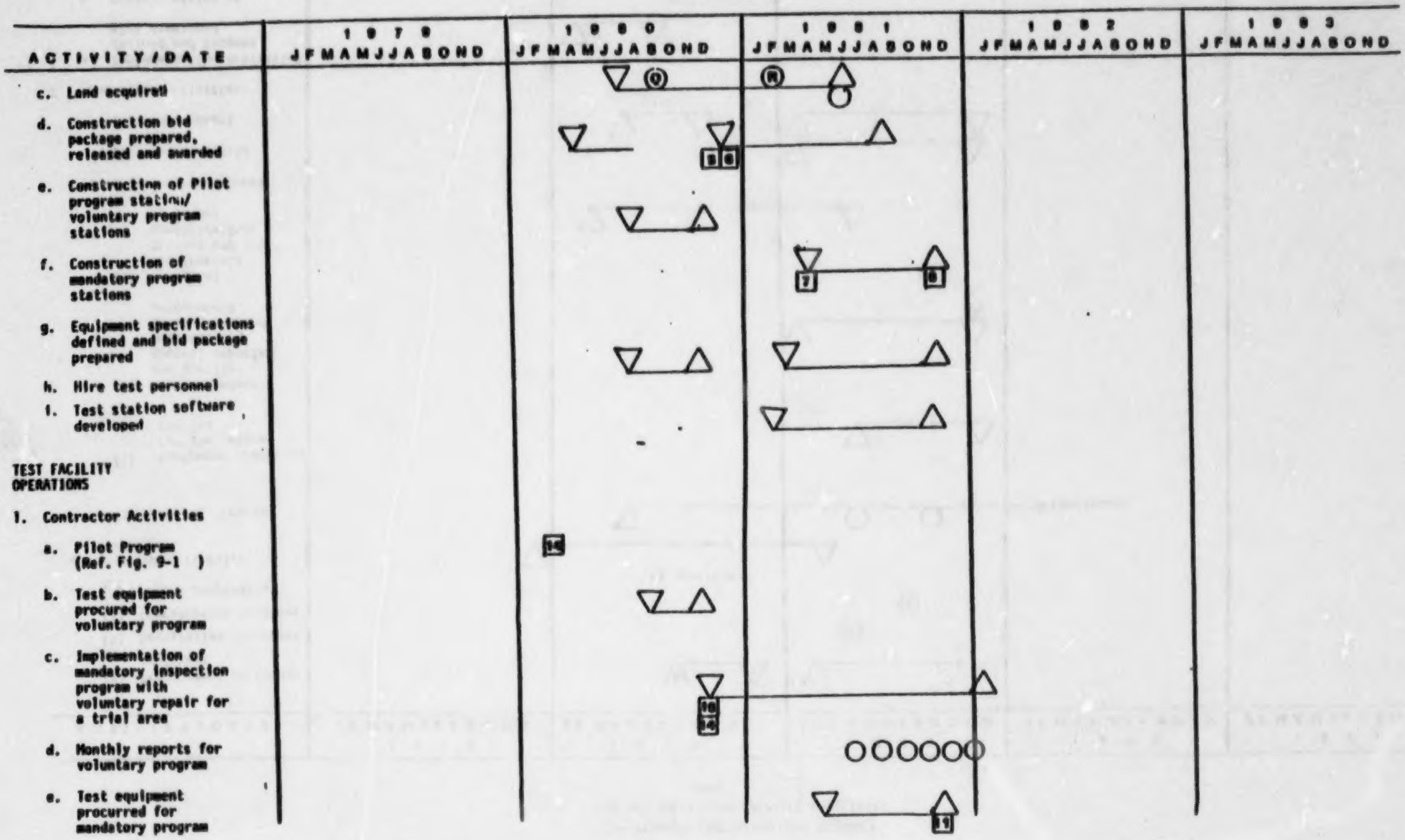


Figure 9-3

I/M PROGRAM IMPLEMENTATION SCHEDULE
FOR THE CONTRACTOR OPERATED FACILITIES
Sheet 5 of 5

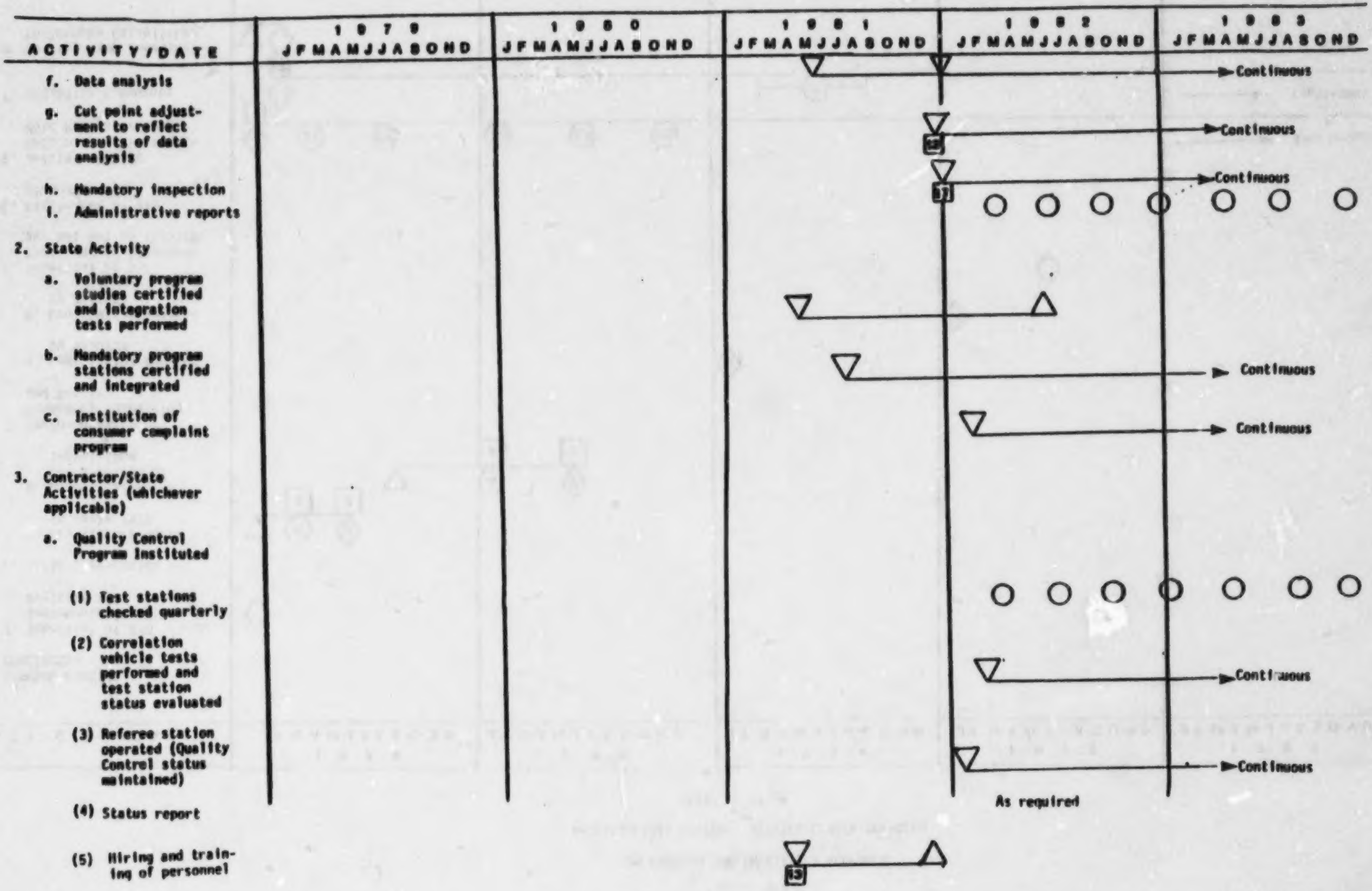


Figure 9-4

I/M PROGRAM IMPLEMENTATION SCHEDULE

DECENTRALIZED SYSTEM - SERVICE CENTER OPERATED

Sheet 1 of 3

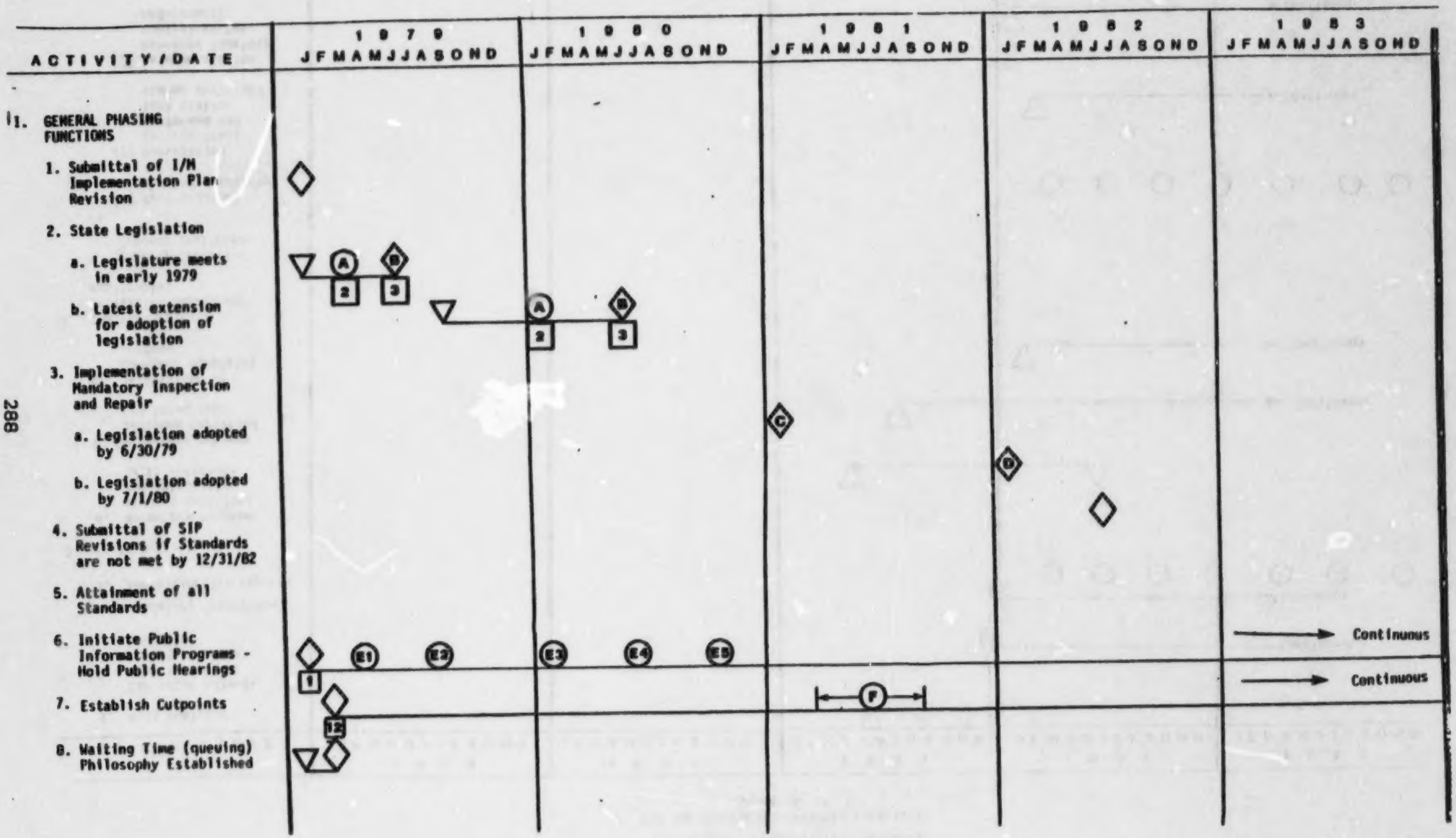


Figure 9-4

I/M PROGRAM IMPLEMENTATION SCHEDULE

DECENTRALIZED SYSTEM- SERVICE CENTER OPERATED

Sheet 2 of 3

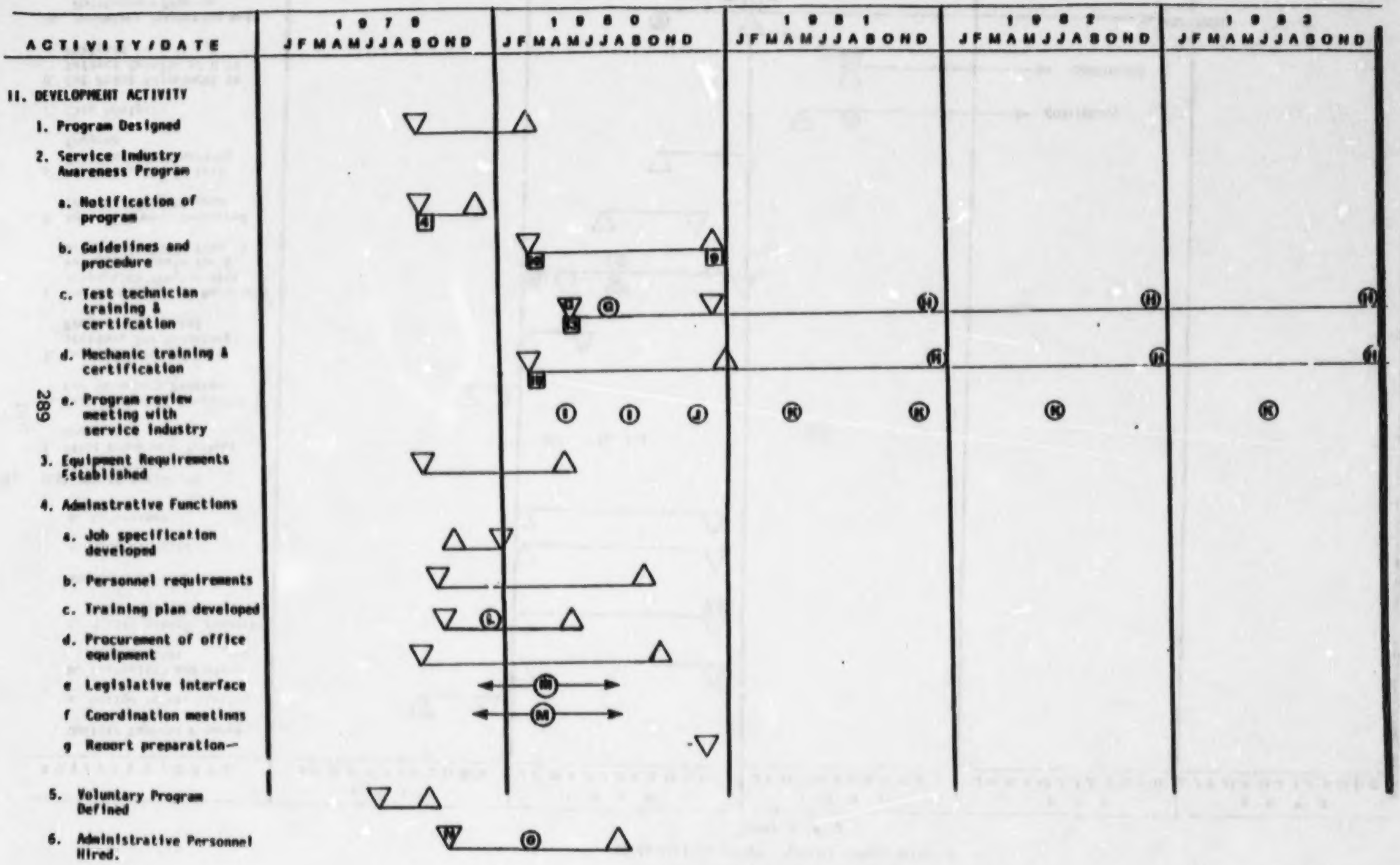


Figure 9-4

I/M PROGRAM IMPLEMENTATION SCHEDULE

DECENTRALIZED SYSTEM - SERVICE CENTER OPERATED

Sheet 3 of 3

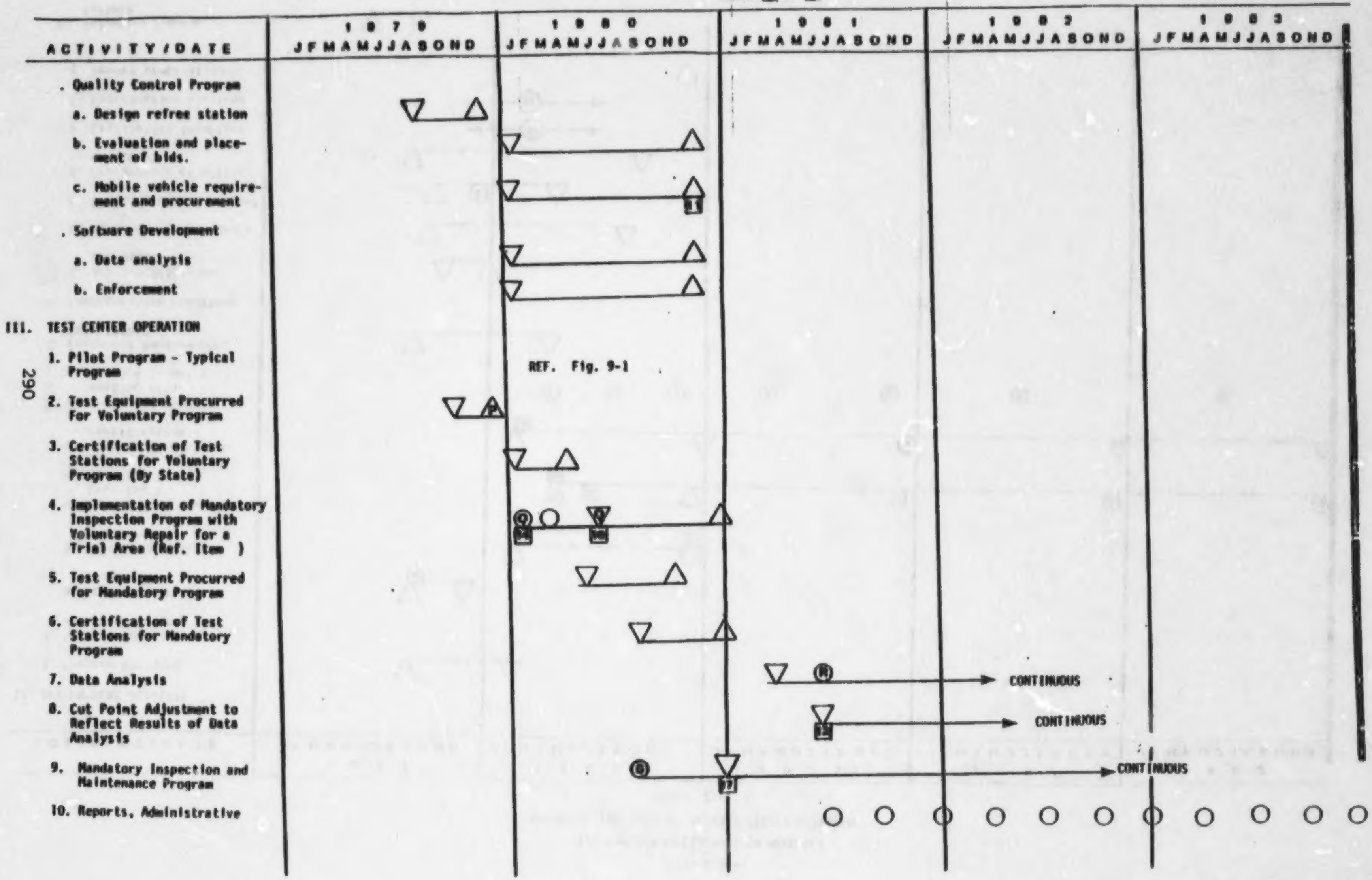


Table 9-2. ITEMS REQUIRED BY USEPA IN THE IMPLEMENTATION SCHEDULE

"1. Initiation (or continuation) of public information program including publicizing the I/M program in the media, meeting and speaking with affected interest groups, etc.

2. Preparation of a draft legislative package and submittal of legislation package to legislature if additional legislative authority is needed.

3. Certification of adequate legal authority by appropriate state official.

4. Initial notification of garages explaining program and schedule of implementation.*

5. Development and issuance of RFPs.*

6. Award to contractor(s).*

7. Initiation of construction of facilities.*

8. Completion of construction of facilities.*

9. Adoption of procedures and guidelines for testing and quality control including emission analyzer requirements (and licensing requirements for private garages, if applicable*).

10. Notification of and explanation to garages of actions in step 9.*

11. Completion of equipment purchase and delivery of equipment.

12. Development and adoption of cutpoints.

13. Initiation of hiring and training of inspectors or licensing of garages.*

14. Initiation of introductory program (voluntary maintenance with either voluntary or mandatory inspection) if not previously initiated.

15. Initiation of mechanics training and/or information program.

16. Initiation of mandatory inspection.

17. Initiation of mandatory repair for failed vehicles.

*Dependent on type of system chosen (state-run centralized, contractor centralized, or decentralized).

TABLE 9-3. FOOTNOTES FOR MIS-I (Figure 9-2)

A) Submit Draft Legislation to Legislature

B) Adopt Legislation Providing Adequate Legal Authority to Define Functional Organization - Adopt Budget

C) Implementation of I/M Program is Required by December 31, 1980, if Legislation is Promulgated by June 30, 1979

D) Implementation of I/M Program is Required by 1981 if Extension Has Been Granted Because Legislation Was Not Promulgated until July 1, 1980. Note: Schedule as Laid Out is for Implementation of Program by December 31, 1981, All Items Would be Extended One Year.

E) Public Hearings

  1) On Proposed Legislation
  2) On Preliminary Program Definition
  3) On Final Program Definition
  4) On Preliminary Implementation Plan
  5) On Final Implementation Plan

F) First Operational Adjustment of Cut Points

G) R.F.Q. Initiated to Provide for Design Service

H) General Design Layout

I) First Area Specific Design

J) Final Area Design

K) First Unit Land Site Defined - Offer/Negotiate for Land

L) First Unit Land Acquired

M) Final Station Land Acquired

N) Final Construction of Trial Program Facilities

O) Service Industry Program Review

P) Initial Mechanics Trained for First Area Operations

Q) Trial Program Activities Program

R) As Required Monthly

S) Final Administrative Personnel Hired

T) Final Training of Administrative Personnel

U) Initial Equipment Delivery to Trial (Voluntary) Area

V) Initial Cut Point Analysis

W) Continuous Training of Personnel

Table 9-4. FOOTNOTES FOR MIS-II (FIGURE 9-3)

A) Submit Draft Legislation to Legislature

B) Adopt Legislation Providing Adequate Legal Authority to Define Functional Organization - Adopt Budget

C) Implementation of I/M Program is Required by December 31, 1980, if Legislation is Promulgated by June 30, 1979

D) Implementation of I/M Program is Required by 1980 if Extension Has Been Granted Because Legislation Was Not Promulgated until July 1, 1980. Note: Schedule as Laid Out is for Implementation of Program by December 31, 1980. To Effect a Schedule for Implementation of a Program by December 31, 1981, All Items Would be Extended One Year.

E) Public Hearings

1) On Proposed Legislation
2) On Preliminary Program Definition
3) On Final Program Definition
4) On Preliminary Implementation Plan
5) On Final Implementation Plan

F) First Operational Adjustment of Cut Points

G) Service Industry Program Review

H) Initial Mechanics Trained for First Area Operations

I) Continuous Program Review with Service Industry

J) Training Plan for Trial Program

K) As Required Monthly

L) Final Administrative Personnel

M) Final Training of Administrative Personnel

N) General Design Layout

O) First Area Specific Design Completed

P) Final Test Station Designed

Q) First Unit Land Site Defined - Offer/Negotiate for Land

Table 9-4. FOOTNOTES FOR MIS-II (FIGURE 9-3) (Continued)

R) First Unit Land Acquired

S) First Station Land Acquired

T) Trial Program Activity

U) Initial Equipment Delivery to Trial (Voluntary) Area

V) Initial Cut Point Analysis

Table 9-5. FOOTNOTES FOR MIS-III (Figure 9-4)

A) Submit Draft Legislation to Legislature

B) Adopt Legislation Providing Adequate Legal Authority to Define Functional Organization - Adopt Budget

C) Implementation of I/M Program is Required by December 31, 1980, if Legislation is Promulgated by June 30, 1979

D) Implementation of I/M Program is Required by 1981 if Extension Has Been Granted Because Legislation Was Not Promulgated Until July 1, 1980. Note: Schedule as Laid Out is for Implementation of Program by December 31, 1980. To Effect a Schedule for Implementation of a Program by December 31, 1981, All Items Would be Extended One Year.

E) Public Hearings

1) On Proposed Legislation
2) On Preliminary Program Definition
3) On Final Program Definition
4) On Preliminary Implementation Plan
5) On Final Implementation Plan

F) First Operational Adjustment of Cut Points

G) Initial Training and Certification for Trial Program

H) Recertification on a Yearly Basis

I) Preliminary Review of Program with the Service Industry

J) Final Review of Program Prior to Operation

K) Continuous Program Review with Service Industry

L) Training Plan for Trial Program

M) As Required Monthly (Or as Needed)

N) Program Director Appointed

O) Main Staff Appointed

P) Initial Equipment Delivery to Trial (Voluntary) Area

Q) Test Personnel Employed

R) Initial Cut Point Analysis

S) Initial Facility Staff Employed

Part IV

REFERENCES AND BIBLIOGRAPHY

1. Bureau of Vehicular Emission Inspection, Arizona Department of Health Services, Arizona Vehicular Emissions Inspection Program Operation 1977, April 1978.

2. Campau, R.M. "Low Emission Concept Vehicles." Paper No. 710294. (Paper presented at the Automotive Engineering Congress, Detroit, Michigan, January 11-15, 1971.)

3. Carlson, R.C. Report "Effect of Automotive and Engine Emissions, Phase 1 - Original Equipment, prepared for U.S. EPA, SCI, Anaheim, December 1976.

4. Chew, M.F., "Auto Smog Inspection at Idle Only," SAE PAPER 69-0505, May 19, 1969.

5. Clean Air Research Company, "An Evaluation of the Effectiveness of Automobile Engine Adjustments to Reduce Exhaust Emissions."

6. Cline, E.L., and Tinkham, L., "A Realistic Vehicle Emission Inspection System," Clayton Manufacturing Company, APCA Paper 68-152.

7. DeGiorgio, J., "Modern Automotive Diagnosis and Evaluation," published by Palm Graphics, Inc., Newport Beach, California, 1967.

8. Durant, J.B. and L. Eltinge, SAE Paper No. 3R, Annual Meeting, January 1959.

9. Elston and Cooperthwait, "New Jersey's Auto Emission Inspection Program, An Assessment of One YEar's Mandatory Operations," June 1975.

10. Evaluation of Restorative Maintenance on 1975 and 1976 Light-Duty Vehicles in Detroit, Michigan.

11. Fosberry, R.A.C. and D.E. Gee, Motor Industry Research Association Report NO. 1961/5, July 1961.

12. Gafford, R. and Carlson, R. "Evaluation of Restorative Maintenance on 1975 and 1976 Light-Duty Vehicles." EPA-460/3-76-032, May 1977.

13. Guthman, Lewis E., Mobile Source Emission Model, United States Environmental Protection Agency January 1978.

14. Hilyard, D. "Evaluation of Short Cycle Test Equipment for In-Use Vehicle Testing. Research Proposal Submitted to EPA (RFP No. DV-78-B164), SCI, Anaheim, California.

15. Jagel, K.I. and F.G. Dwyer. HC/CO Oxidation Catalysts for Vehicle Exhaust Emission Control. Paper No. 710290. (Paper presented at the Automotive Engineering Congress, Detroit, Michigan, January 11-15, 1971.)

16. Jueja, W.K., D.D. Horchler, and Haskew, H.M. "A Treatise on Exhaust Emission Test Variability" Paper No. 770136, presented at the SAE International Automotive Engineering Congress and Exposition, Cobo Hall, Detroit, February 28-March 4, 1977.

Preceding page blank

17. Kincannon, B.F. and A.H. Castaline. "Information Documents on Automobile Emissions Inspection and Maintenance Programs - Final Report," EPA, Report 400/2-78-001, February 1978.

18. Mercedes-Benz diesel trucks - economy data ASP-77-211-10-CVR1 data sheet, September, 1977.

19. Northrop Corporation, "Mandatory Vehicle Emission Inspection and Maintenance," V.5, 1971.

20. Olson Laboratories (SCI), "Degradation Effects on Motor Vehicle Emissions," March 1976.

21. Olson Laboratories, Inc. - Effectiveness of Short - Emission Inspection Tests in Reducing Emissions through Maintenance, Anaheim, California, July 31, 1972.

22. Olson Laboratory Report "Phase I, Final Report for Vehicle Emissions Testing Station (VETS) for the City of Chicago, Department of Public Works, 1972.

23. Olson Laboratories, Inc. (SCI), "The Short Cycle Project, Effectiveness of Short Emission Inspection Tests in Reducing Emissions Through Maintenance", Anaheim, California, 1973.

24. Olson Laboratories, Inc. (SCI), "South Coast Air Basin Vehicle Emission Inspection Program Design Study - Final Report". Vol. III Appendicies, Prepared for State of California Department Consumer Affairs, Bureau of Automotive Repair, Anaheim, California, 1975.

25. Olson Laboratories, Inc. (SCI), - "Vehicle Emission Inspection and Control Program, Final Report, Vol. 2, Technical Analysis and Results," 1972.

26. Olson Laboratories, Inc. (SCI), "Vehicle Emissions Inspection and Control Program - State of Colorado", Anaheim, California, 1972.

27. Olson Laboratories, Inc. (SCI), "Vehicle Emission Testing Program, Concept and Criteria Phase, City of Chicago", Anaheim, California, 1973.

28. Olson Laboratories, Inc. (SCI), "Vehicle Emissions Testing Program, for the City of Chicago", Anaheim, California, 1973.

29. Reschke, G.D., "Optimization of a Flame Ionization Detector for Determination of Hydrocarbons Diluted Automotive Exhaust", Paper Presented at SAE International Automotive Engineering Congress, Detroit, Michigan, February 1977.

30. Rubenstein, G., R. Ingles, R. Weis, and A. Wong, "Vehicle Inspection and Maintenance - The California Program," paper presented to Society of Automotive Engineers, 1976.

31. Schlingmann, S.N. "Vehicle Exhaust Emission Instruments Evaluation". EPA-460/3-77-014, July 1977.

32. Scott Research Laboratories, Inc., "Exhaust Emissions and Test Evaluation of the State of California Roadside Idle Emission Inspection Program", 1975.

33. Seliber, J. and H.W. Poston, "Chicago's Experience in Vehicle Emission Testing". SAE No. 760368, Automotive Engineering Congress and Exposition, Detroit, Michigan, February 23-27, 1976.

34. Smith, F. and Nelson, A.C. "Guidelines for Development of A Quality Assurance Program". EPA-R4-73-028a, June 1973.

35. State of California, California Air Resources Board, Evaluation of Mandatory Vehicle Inspection and Maintenance Programs, August 2, 1976.

36. State of California, California Air Resources Board, "765-1975-1976 Model-year Surveillance Test Program Report", March 1978.

37. State of California, Bureau of Automotive Repair, "California Vehicle Inspection Program Riverside Trial Program Report. Operations from September 2, 1975 to February 13, 1976," Volumes 1 and 2.

38. U.S. Department of Health, Education and Welfare, Second Report of the Secretary of HEW to the Congress of the U.S. in compliance with PL 90-148, the Air Quality Act of 1967, dated January 1969.

39. U.S. Department of Transportation, "Evaluation of Diagnostic Analysis and Test Equipment For Small Automotive Repair Establishments", July 1978.

40. U.S. EPA: Appendix N - Emission Reduction Achievable through Inspection and Maintenance of Light-Duty Vehicles, Motorcycles, and Light- and Heavy-Duty Trucks. Proposed Rule. Federal Register, 24 (84); 22177-22183, May 2, 1977.

41. U.S. EPA, "Control Strategies for In-Use Vehicle," November 1972.

42. U.S. EPA, "Mobile 1: Mobile Source Emissions Model", August 1978.

43. U.S. EPA, "Mobile Source Emission Factors for Low-Altitude Areas," EPA-400/9-78-DOT, March 1978.

44. EPA, "A Study of Emissions From Light-Duty Vehicles in Denver, Houston and Chicago, Fiscal Year 1972". Ann Arbor, Michigan 1973.

45. U.S. EPA, "Supplement No. 5 for Compilation of Air Pollutant Emissions Factors," 2nd Edition, December 1975.

46. U.S. Government "Code of Federal Regulations," 40 CFR, July 1, 1977.

47. U.S. Government Federal Register, Part 205 Transportation Equipment Noise Emission Controls, Title 40, Chapter 1, dated October 30, 1974 and May 28, 1975, Sections 6, 10, 11, and 13 of the Noise Control Act of 1972; 86 Stat. 1234, Public Law 92574 (The Act).

48. Vulliamy, M. and J. Spiers, S.A.E. Paper No. 670090, Automotive Engineering Congress, Detroit, January 1967.

49. Williams, Marcia E., Computer Simulation of Emission Inspection Procedures - Assessment of Effectiveness, Society of Automotive Engineers, 1976.

50. Wimette, H., R. Pilkington and T. Kelley. "Guidelines for Quality Assurance Programs for Mobile Source Emissions Measurement Systems: Phase I, Light-Duty Gasoline Powered Vehicles - Quality Assurance Guidelines. EPA-650/4-75-024-a. June 1975.

51. Transportation Energy Conservation Book, 2nd. edition.

52. State of Tennessee, Correspondence, November 1978.

53. State of California, El Monte Air Pollution Laboratory, Telephone Communication, December 14, 1978.

54. State of Oregon, "Oregon Environmental Quality Commission, Report to the Oregon Legislature on the Motor Vehicle Emission Testing Program," 1977.

55. U.S. EPA Inspection/Maintenance Policy. A Memo from Assistant Administrator for Air and Waster Management to Regional Administrators, Regions I-X, Ann Arbor, Michigan, July 17, 1978.

56. U.S. EPA, "Appendix "N" Emission Credits Given in Code of Federal Regulations", dated July 21, 1978, proposed credits, final credits are pending.

57. 1979 Dodge Manual for Building Contruction Pricing and Scheduling, McGraw-Hill Information Systems Company, New York, New York, 1979.

Part V

APPENDICES

Appendix A

MEMO FROM THE UNITED STATES EPA TO REGIONAL EPA ON I/M POLICY

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
ANN ARBOR, MICHIGAN 48105

JUL 17 1978

OFFICE OF
AIR AND WATER PROGRAMS

RECEIVED
JUL 19 1978
Air Programs Branch
AHMD US EPA Region V

SUBJECT: Inspection/Maintenance Policy

FROM: David G. Hawkins, Assistant Administrator
for Air and Waste Management

MEMO TO: Regional Administrators, Regions I - X

As you know, the Clean Air Act Amendments of 1977 set forth specific requirements for the implementation of motor vehicle inspection/maintenance (I/M) programs. Attached is a policy paper indicating what EPA will consider a minimally acceptable program wherever I/M is required by the Act. It should aid your efforts to provide for adequate I/M submissions for the State Implementation Plan (SIP) revisions of January 1, 1979. Please continue to contact me if problems in I/M implementation develop.

cc: Air and Hazardous Materials Division
  Directors, Regions I, III - X
 Environmental Programs Division Director,
  Region II
 Air Programs Branch Chiefs, Regions I - X

Reproduced from
best available copy.

JL

Preceding page blank

Policy for the Development and Implementation of Inspection/Maintenance Programs

The Clean Air Act Amendments of 1977 provide new direction for the development and implementation of motor vehicle inspection/maintenance (I/M) programs. If states are not able to demonstrate attainment of the standards for oxidant (Ox) or carbon monoxide (CO) by December 31, 1982, a specific schedule for the implementation of I/M must be included in the State Implementation Plan (SIP) revisions of January 1, 1979 for the plan to meet the requirements of Section 172. The general requirements for the I/M programs are set out in a February 24, 1978 memorandum from the EPA Administrator to the Regional Administrators (reprinted in the Federal Register on May 19, 1978, 43 F.R. 21673). The requirements, for these programs, are explained in more detail below.

A. I/M SIP Revision Development and the January 1, 1979, Submittal

In producing an I/M SIP revision, the states should provide for:

1. an analysis of the benefits and costs of the program;
2. a public information effort;
3. a legislative proposal; and
4. a schedule for I/M implementation.

A copy of suggested steps for development of the SIP revision is attached (Attachment 1). Before the January 1, 1979 submittal, the SIP revision must be adopted by the state air pollution control board or agency head as appropriate. As a part of the SIP revision submittal itself, there must be a commitment by the Governor to implement the I/M program according to the schedule submitted.*

---

*Sections 172(b)(7) and (10) provide that the plan revisions required for nonattainment areas shall —

(7) identify and commit the financial and manpower resources necessary to carry out the plan provisions required by this subsection; [Emphasis added]

and shall —

(10) include written evidence that the state, the general purpose local government or governments, or a regional agency designated by general purpose local governments for such purpose, have adopted by statute, regulation, ordinance, or other legally enforceable document, the necessary requirements and schedule and timetables for compliance, and are committed to implement and enforce the appropriate elements of the plan; [Emphasis added]

These plan elements should be prepared in accordance with the guidance on pages 186-188 of the Compilation of Presentations prepared by EPA's Office of Air Quality Planning and Standards (OAQPS) for the "Workshops on Requirements for Nonattainment Area Plans" February -March 1978 (pages 218-220 in the April 1978 edition).

B. The I/M Implementation Schedule

The specific items listed below must be included as a part of the States' I/M implementation schedules with specified dates for implementation of each item. The stringency planned for the program and other factors affecting the potential for emission reductions should also be indicated. Additional items if necessary because of local factors may be required by USEPA Regional Offices.

1. Initiation (or continuation) of public information program including publicizing the I/M program in the media, meeting and speaking with affected interest groups, etc.
2. Preparation of a draft legislative package and submittal of legislation package to legislature if additional legislative authority is needed.
3. Certification of adequate legal authority by appropriate state official.
4. Initial notification of garages explaining program and schedule of implementation.*
5. Development and issuance of RFPs.*
6. Award to contractor(s).*
7. Initiation of construction of facilities.*
8. Completion of construction of facilities.*
9. Adoption of procedures and guidelines for testing and quality control including emission analyzer requirements (and licensing requirements for private garages, if applicable*).
10. Notification of and explanation to garages of actions in step 9.*

11. Completion of equipment purchase and delivery of equipment.

12. Development and adoption of cutpoints.

13. Initiation of hiring and training of inspectors or licensing of garages.*

14. Initiation of introductory program (voluntary maintenance with either voluntary or mandatory inspection) if not previously initiated.

15. Initiation of mechanics training and/or information program.

16. Initiation of mandatory inspection.

17. Initiation of mandatory repair for failed vehicles.

If certification of adequate legal authority occurs after January 1979, the States may modify previous commitments to implement and enforce the elements of the schedule to conform to the legal authority.** These modifications will be approved by the EPA Regional Offices and must be consistent with the Administrator's February 24, 1978, policy memorandum. The documents should be submitted to the EPA Regional Offices for inclusion in the SIP revisions already submitted by January 1, 1979. Any necessary adjustments to the schedule may be made at this time but must be approved by the EPA Regional Offices.

C. Authority to Implement I/M

Normally, adequate legal authority to implement a SIP revision must exist for a revision to be approved. Where a legislature has had adequate opportunity to adopt enabling legislation before January 1, 1979, the Regional Administrator should require certification that adequate legal authority exists for I/M implementation by January 1, 1979. However, for many states there will be insufficient opportunity to obtain adequate legal authority before their legislatures meet in early 1979. Therefore, a certification of legal authority for the implementation of [illegible] in these states must be made no later than June 30, 1979. An extension to July 1, 1980, is possible, but only when the state can demonstrate that (a) there was insufficient opportunity to conduct necessary technical analyses and/or (b) the legislature has had no opportunity to consider any necessary enabling legislation for inspection/ maintenance between enactment of the 1977 Amendments to the Act and June 30, 1979. Certification of adequate legal authority, or other evidence that legal authority has been adopted, must be submitted to the EPA Regional Offices to be included in the SIP revision already submitted. Failure to submit evidence of legal authority by the appropriate deadline will constitute a failure to submit an essential element of the SIP, under Sections 110(a)(2)(I) and 176(a) of the Act.

---

*Dependent on type of system chosen (state-run centralized, contractor centralized, or decentralized).

**See footnote on page 1.

Reproduced from best available copy.

Prior to the respective deadlines for initiating mandatory inspection and mandatory repair of failed vehicles, the state, local government, or regional agency should adopt whatever legally enforceable requirements are necessary to ensure that vehicles are not used unless they comply with the inspection/maintenance requirements. Written evidence of adoption of these requirements should be submitted to the EPA Regional Offices, to be included in the SIP revision already submitted by January 1, 1979.*

D. I/M Implementation Deadlines

Implementation of I/M "as expeditiously as practicable" shall be defined as implementation of mandatory repair for failed vehicles no later than two and a half years after passage of needed legislation or certification of adequate legal authority for new centralized systems and one and a half years after legislation or certification for decentralized systems or for centralized systems which are adding emission inspections to safety inspections. For the normal legislation deadline of June 30, 1979, new centralized programs must start by December 31, 1981, and all others must start by December 31, 1980. For the case of the latest possible legislation date, July 1, 1980, this means that a new centralized program must start by December 31, 1982, while all other programs must start by December 31, 1981. Where I/M can be implemented more expeditiously, it must be. Each state implementation schedule must be looked at individually to determine if it is as expeditious as practicable. Implementation dates ordered by courts, if earlier than these dates, take precedence.

E. Geographic Coverage

I/M should focus on metropolitan areas and should include the entire urbanized area and adjacent fringe areas of development. Boundaries of the area affected may be adjusted if an equivalent emission reduction is achieved. For urbanized areas of 200,000 population or greater which need I/M to obtain an extension of the 1982 attainment date, full mandatory I/M must be implemented by the deadlines indicated above. Statewide programs are encouraged, especially for those states which are small and highly urbanized.

It should be emphasized that all nonattainment areas must have SIPs which are adequate to attain and maintain the National Ambient Air Quality Standards (NAAQS) by 1982 or by no later than 1987 should an acceptable nonattainment demonstration be made. For areas under 200,000, EPA will not at this time automatically require I/M schedules in 1979 as a condition for SIP approval or an extension. However, areas under 200,000 still have to attain and maintain NAAQS as expeditiously as practicable, and I/M is encouraged as a means of helping to provide for an adequate SIP. EPA will review the need for I/M in areas under 200,000 after the 1979 SIP revisions are submitted, and will consider additional requirements at that time.

---

*See footnote on page 1.

F. Emission Reductions Required for I/M

I/M programs must produce at least a 25 percent reduction in light duty vehicle (LDV) exhaust emissions of hydrocarbons and a 25 percent reduction in LDV emissions of carbon monoxide by December 31, 1987, compared to what emissions would be without I/M on the basis of the most recent motor vehicle emission factors. However, the choices of stringency factor to be used and other actions affecting the potential for emission reduction should be made by the states. States should of course be encouraged to develop programs which produce more emission reduction when possible. The final revision to Appendix N (40 C.F.R., Part 51) when promulgated (along with its minimum program requirements) should be used to determine if the program described in the implementation schedule will meet the minimum 25 percent CO/25 percent HC criterion. Should a program not need to be this stringent to attain and maintain the NAAQS by 1982, the I/M program need be only as stringent as needed to assure conformity with NAAQS. Should a state want to emphasize control of one particular pollutant at the expense of the other, the plan for such an I/M program must be submitted to the appropriate EPA Regional Office for approval.

G. Minimum Program Requirements

In addition to the emission reduction requirement above, all I/M programs must:

1. provide for regular periodic inspections of all vehicles for which emission reductions are claimed;*

2. provide for maintenance and retesting of failed vehicles to provide for compliance with applicable emission standards;

3. prohibit registration or provide some equally effective mechanism to prevent vehicles which do not comply with the applicable exhaust emission requirements from operating on public roads;

4. provide for quality control regulations and procedures for the inspection system including:

---

*Random roadside checks, while a useful addition to an I/M program, are not an acceptable substitute for regular periodic inspections.

a. minimum specifications for emission analyzers

b. required calibrations of all types on analyzers and

c. minimum record keeping;

5. provide for either a mechanics training program or a program to inform the public of service establishments with approved emission analyzers; and

6. inform the public of the reason for the I/M program plus the locations and hours of inspection stations.

Decentralized systems must also comply with the following requirements.

1. All official inspection facilities must be licensed. Provisions for the licensing of inspection facilities must insure that the facility has obtained, prior to licensing, analytical instrumentation which has been approved for use by the appropriate state, local, or regional government agency. A representative of the facility must have received instructions in the proper use of the instruments and in vehicle testing methods and must have demonstrated proficiency in these methods. The facility must agree to maintain records and to submit to inspection of the facility. The appropriate government agency must have provisions for penalties for facilities which fail to follow prescribed procedures and for misconduct.

2. Records required to be maintained should include the description (make, year, license number, etc.) of each vehicle inspected, and its emissions test results. Records must also be maintained on the calibration of testing equipment.

3. Summaries of these inspection records should be submitted on a periodic basis to the governing agency for auditing.

4. The governing agency should inspect each facility periodically to check the facilities' records, check the calibration of the testing equipment and observe that proper test procedures are followed.

5. The governing agency should have an effective program of unannounced/unscheduled inspections both as a routine measure and as a complaint investigation measure. It is also recommended that such inspections be used to check the correlation of instrument readings among inspection facilities.

6. The governing agency should operate a "referee" station where vehicle owners may obtain a valid test to compare to a test from a licensed station. At least one "referee" station must be present in each I/M metropolitan area.

Attachment 1
Suggested I/M Milestones

1. Complete plan for preparing and implementing I/M SIP revision including:
    a. technical analysis
    b. public information program
    c. development of necessary legislation
    d. development of I/M implementation schedule.
2. Complete technical analysis including:
    a. emission reduction benefits
    b. fuel economy benefits
    c. costs.
3. Complete elements of a continuing public information program including:
    a. further publicity concerning oxidant (and/or carbon monoxide) episodes
    b. meeting with and speaking to affected interest groups (including the public and public officials)
    c. news releases.
4. Complete development of legislative proposals.
5. Complete development of I/M implementation schedule.
6. Receive approval of I/M, including implementation schedule, from air pollution control board or agency head as applicable and introduce into state legislature.
7. Submit SIP revision for I/M, including implementation schedule, to EPA (due no later than January 1, 1979).
8. Obtain legal authority needed to implement I/M (required by July 1, 1979, with some exceptions allowed until July 1, 1980).

Appendix B

EFFECT OF STRINGENCY FACTOR

Choice of stringency factor determines the total number of required tests with a given vehicle population. Higher stringency factors require more tests, this increases the load on existing (or undetermined) testing lanes.

Assuming only one retest per failed vehicle, the relationship between number of tests and stringency factor is shown in the following equation:

$$T_1 = N + N \times SF$$

where:

T_1 = number of required tests
N = vehicle population subject to inspection
SF = stringency factor (from 0 to 100 percent)

For retests per failed vehicle, the relationship should be:

$$T_2 = N + N \times SF + N \times SF \times P_2$$

where:

P_2 = the percent of vehicles that require a second retest

Based on conditions of vehicle and quality of repair work, the failed vehicle may or may not be required to have a second retest.

Preceding page blank

Figure B-1 depicts the relationship between the number of tests (T_1) and the stringency factor (SF). For convenience, scale of the number of required tests is based on 100 vehicles. In the figure, an upper bound for second retest condition has been established.

For these retest requirements, the relationship is as follows:

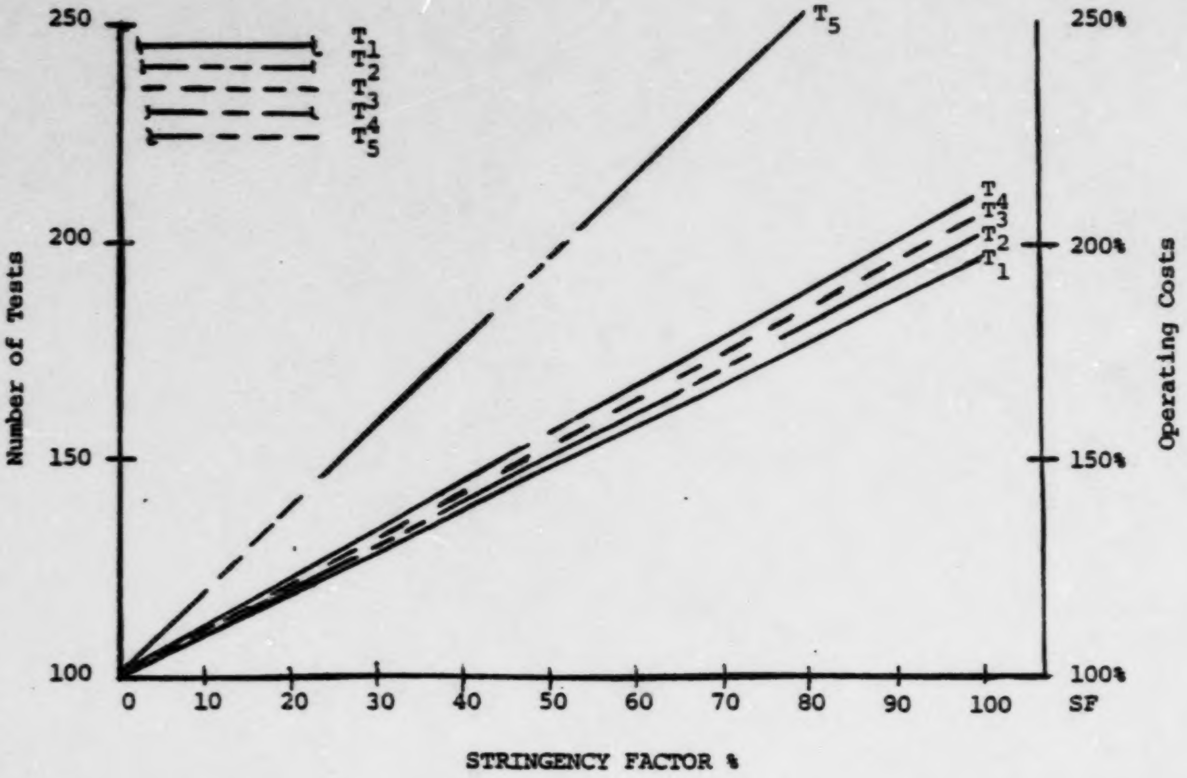
$$T_3 = N + N \times SF + N \times SF \times P_2 + N \times SF \times SF \times P_2 \times P_3$$

where:

P_3 = is the probability that a failed vehicle would require a third retest.

The same reasoning can be extended to more than three retest requirements. However, for social/economic/public reasoning a third retest is not a feasible option.

Figure B-1, also displays the operating cost versus stringency factor. In general, operating cost is approximately proportioned to total number of required tests. Additional capital cost are not required where testing lanes are organized under extended work week. Normally, operating hours may be 8 hours a day, 5 days a week. Considering possible increased working hours with two shifts of crews, it may extend to 16 hours a day, 7 days a week. This allows a maximum factor of 2.8 (= 16/8 x 7/5) which may be used for determining the annual lane output rate.



Based on 100 Vehicles

1. T_1 = 100 + 100 x SF
2. T_2 = 100 + 100 x SF + 100 x SF x .05
3. T_3 = 100 + 100 x SF + 100 x SF x .10
4. T_4 = 100 + 100 x SF + 1-- x SF x .15
5. T_5 Upper boundary for second test.

$T_{2,3,4}$ = 100 + 100 x SF + 100 x SF x P_2
Where P_2 = 0.5, 0.10. 0.15

Figure B-1. TEST REQUIREMENTS AND OPERATING COSTS VERSUS STRINGENCY FACTOR

Appendix C

EMISSION CREDITS GIVEN IN THE CODE OF FEDERAL REGULATIONS

Appendix N - Emission Reductions Achievable Through Inspection, Maintenance of Light-Duty Vehicles, Motorcycles, and Light- and Heavy-Duty Trucks.

ENVIRONMENTAL PROTECTION AGENCY

[40 CFR Part 51]

[FRL 703-4]

APPENDIX N—EMISSION REDUCTIONS ACHIEVABLE THROUGH INSPECTION AND MAINTENANCE OF LIGHT DUTY VEHICLES, MOTORCYCLES, AND LIGHT AND HEAVY DUTY TRUCKS

AGENCY: Environmental Protection Agency.

ACTION: Proposed rule.

SUMMARY: This Appendix presents estimates of potential emissions reduction benefits which, in the judgment of the Administrator, are likely to be achievable through the application of a properly structured and managed inspection/maintenance (I/M) program. Estimates of emission reductions available through retrofit programs, formerly contained in Appendix N, have been deleted. Inspection/Maintenance program effectiveness is given as a function of the level of technology, the stringency of emission standards, the length of program operation, and the adequacy of mechanic training. Basic program requirements are outlined for both the centralized and decentralized program concept. Attachment 1 provides a discussion of the modeling techniques utilized to generate the emission reduction estimates, while Attachment 2 provides computational examples illustrating the usage of Appendix N.

FOR FURTHER INFORMATION CONTACT:

John O. Hidinger, Director, Office of Transportation and Land Use Policy (AW-445) U.S. Environmental Protection Agency, 401 M Street SW., Washington, D.C. 20460 (202-755-0480).

ADDRESS: Submittal of Comments: Comments upon Appendix N are requested. Such comments should be directed to the individual below and postmarked no later than August 1, 1977.

Dated: April 19, 1977.

DOUGLAS M. COSTLE,
Administrator.

In Part 51, of Title 40, Code of Federal Regulations, Appendix N is revised to read as follows:

APPENDIX N—EMISSION REDUCTIONS AND ACHIEVABLE THROUGH INSPECTION AND MAINTENANCE OF LIGHT DUTY VEHICLES, MOTORCYCLES, AND LIGHT AND HEAVY DUTY TRUCKS

AUTHORITY: Section 301(a) of the Clean Air Act as amended by section 15(c)(2) of Pub. L. 91-604, 84 Stat. 1713; 81 Stat. 504 (42 U.S.C. 1857g(a)).

1. *Introduction.* This Appendix presents estimates of the potential emissions reduction benefits which, in the judgment of the Administrator, are likely to be achievable through the application of a properly structured and managed inspection/maintenance (I/M) program. Since the publication of the original Appendix N, new data obtained and experience gained from operating programs have shown the necessity for a revision to certain portions of this document. In addition, estimates of emission reductions available through retrofit programs, formerly contained in Appendix N, have been deleted. Retrofit guidance will be placed in a separate appendix consistent with a format to be followed for other strategies.

To the extent possible, estimates in this Appendix are based on empirical data. However, lack of data in several areas has necessitated extrapolation of empirical data using modeling techniques based on sound engineering judgment. A description of these modeling techniques is contained in Attachment 1. As new data become available, or as predicted extrapolations change, this Appendix will be revised and amended accordingly.

Several definitions have been modified to reflect their intended meaning. Most important, "initial failure rate" has been redefined as a "stringency factor." Hopefully, this new definition will dispel past misapprehension concerning the "initial failure rate" concept. In addition, the idle test has been slightly redefined to reflect actual idle emission testing currently being used.

The minimum requirements of an I/M program are defined. Those programs which are contemplating the use of a private garage I/M program should note the special requirements necessary to obtain the basic emission reduction credits.

Emission reductions for light duty vehicles are estimated not only for the first year of an I/M program but also for subsequent years since modeling has shown that the reduction benefits can increase with time. Additional emission reductions are estimated for those programs which include twice-a-year inspection and special mechanic training. Estimates of emission reductions resulting from I/M programs for light-duty trucks, heavy-duty trucks, and motorcycles are also given.

Certification data and recent surveillance data indicate that I/M effectiveness may be greater (especially for carbon monoxide) for catalyst equipped in-use vehicles than for pre-catalyst vehicles. By the time many I/M programs are fully implemented, catalyst-equipped vehicles will dominate the vehicle mix. Estimates are therefore given for the effectiveness of I/M on such vehicles, despite the limited data base at the present time.

Tables 1 through 5 summarize the emission reductions obtainable from I/M pro-

Reproduced from
best available copy.

Preceding page blank

grams. The actual benefit obtained by any state or region implementing a well-designed program may exceed the emissions reductions listed. Such higher reductions, however, would have to be shown through an adequate source surveillance study.

2. *Definitions.* a. "Cutpoint" means the level of emissions which discriminates between those vehicles requiring emission-related maintenance and those that do not.

b. "Federal Test Procedure" (FTP)—A sequence of testing utilized by the Agency to measure vehicle exhaust emissions over a typical urban driving cycle.

c. "Heavy-duty vehicle" means for the purpose of this Appendix, a gasoline fueled motor vehicle whose GVW is greater than 8,500 pounds.

d. "Idle emissions test" or "idle test" means a test procedure for sampling exhaust emissions which requires operation of the engine in the idle mode only. At a minimum, the idle test should consist of the following procedure carried out on a fully warmed-up engine: a measurement of the exhaust emission concentrations for a period of time of at least 15 seconds, shortly after the engine was run at 2,000 to 2,500 rpm with no load for approximately 60 seconds.

e. "Inspection/maintenance" means a strategy to reduce emissions from in-use vehicles by identifying vehicles that need emissions-related maintenance and requiring that such maintenance be performed.

f. "Light-duty vehicle" means a passenger car or passenger car derivative capable of seating 12 persons or less.

g. "Light-duty truck" means, for the purpose of this Appendix, a motor vehicle designed primarily for the transportation of property, or the derivation of such a vehicle, whose GVW is 8500 pounds or less.

h. "Load emissions test" or "loaded test" means a test procedure for sampling exhaust emissions which exercises the engine under loading by use of a chassis dynamometer to stimulate actual driving conditions. As a minimum requirement, the loaded test must include running the vehicle and measuring exhaust emissions at two speeds and loads other than idle.

i. "Motorcycle" means for the purpose of this Appendix, a two-wheeled motorized vehicle designed to transport persons or property on a street or highway.

j. "Stringency factor" is a measure of the rigor of a program based on the estimated fraction of the vehicle population whose emissions would exceed cutpoints for either or both carbon monoxide and hydrocarbons were no improvements in maintenance habits or quality of maintenance to take place as a result of the program.

k. "Tampering" means, for the purpose of this Appendix, rendering inoperative, or intentional misadjustment of any motor vehicle device or element of design intended to control exhaust emissions.

l. "Technology I" means the general type of exhaust emission control technology utilized on all light-duty vehicles subject to pre-1975 Federal emission standards.

m. "Technology II" means the general type of exhaust emission control technology utilized on light-duty vehicles subject to 1975 and later model year federal exhaust emission standards.

3. *Emission reductions for light-duty vehicles.* Tables 1 through 4 list emission reductions for light-duty vehicles that can be achieved through properly structured and managed programs of inspection/maintenance and accompanying mechanic training. See Attachment 1 and 2 for a description of the derivation of these credits and for computational examples of the use of the tables.

a. *First year program credits.* The following first year credits are applicable to both idle and loaded tests.

TABLE 1.—*First year of program credits*

Stringency factor	HC (percent)		CO (percent)	
	Technology I	Technology II	Technology I	Technology II
0.10	1	1	3	8
.20	5	3	6	20
.30	7	9	12	28
.40	10	16	19	33
.50	11	24	22	37

b. *Subsequent years program credit.* The following additional (to Table 1) credits are applicable to vehicles which have undergone more than one inspection by the beginning of the calendar year of interest. These credits are not applicable to programs having inspection intervals of longer than one year. For a model year group of vehicles, the appropriate credit is selected on the basis of the specific number of inspections that the group has incurred by the beginning of the calendar year of interest. The credit is then added to the appropriate first year credit above. Credits are applicable to both technology level cases, to the idle and loaded tests, and to all stringency factor programs.

TABLE 2.—*Subsequent years program credit*

Number of inspections	Additive credit	
	HC (percent)	CO (percent)
2	7	8
3	14	13
4	20	19
5	25	23
6	30	27
7	32	30
8 or more	36	35

c. *Semi-annual I/M program credit.* A credit of 0.2 percent per subsequent semi-annual inspection may be added, up to 15 times, to the first year (Table 1) credits for those programs requiring semi-annual inspection. This credit is applicable at all stringency factors for both HC and CO, idle and loaded tests, and both technology levels.

d. *Mechanic training program credit.* The following additional credits may be taken for the presence of an adequate program of mechanic training.[1] Table 3 provides the basic credits for mechanic training, while Table 4 lists the appropriate credits to be added to Table 3 credits for subsequent years of program operation. The sum of Table 3 and 4 credits is then to be added to the basic credit computed from Tables 1 and 2.

TABLE 3.—*Mechanic training first year credits*

Stringency factor	Technology I		Technology II	
	HC (percent)	CO (percent)	HC (percent)	CO (percent)
0.10	1	5	3	7
.20	3	7	5	10
.30	4	9	4	10
.40	6	8	1	7
.50	7	7	1	5

TABLE 4.—*Mechanic training subsequent year credits*

Technology I

Stringency factor	Number of inspections			
	2		3 or more	
	HC (percent)	CO (percent)	HC (percent)	CO (percent)
0.10	3	3	15	18
.20	4	8	10	15
.30	6	5	9	9
.40	5	5	6	5
.50	3	2	3	2

Technology II

Stringency factor	Number of inspections—3 or more	
	HC (percent)	CO (percent)
0.10	10	4
.20	8	3
.30	2	1
.40	1	3
.50	1	1

The above Table 4 credits are applicable to vehicles which have undergone more than one inspection by the beginning of the calendar year of interest. For a model year group of vehicles, the appropriate credit is selected on the basis of the technology level of the vehicles, the number of inspections the vehicles have incurred by the beginning of the calendar year of interest, and the stringency factor of the I/M program. The credit is then added to the appropriate first year mechanic training credit (Table 3) and the result is added to the basic credit calculated from Tables 1 and 2. Credits are applicable to both the idle and the loaded test.

Inspection/maintenance approaches are expected to be applicable to heavy duty gasoline fueled trucks and motorcycles, as well as light duty vehicles.

a. *Emission reductions for motorcycles and light duty trucks.* The estimated emission reductions for this group of vehicles are the same as those given in Tables 1 through 4 for Technology I light duty vehicles.

b. *Emission reductions for heavy duty trucks.* Estimated emission reductions due to I/M for gasoline fueled heavy duty vehicles, using either an idle or loaded emissions test are as follows:

TABLE 5.—*Heavy duty vehicle I/M credit*[2]

Stringency factor	HC (percent)	CO (percent)
0.20	11.4	8.3
.30	12.3	9.2
.40	13.6	10.5
.50	17.2	12.0

Analysis of data (generated by the City of New York under EPA grant) on 65 trucks indicate that I/M is a potentially viable emission reducing strategy. The estimated emission reductions given above are based on these limited data. No data on the deterioration of trucks with or without I/M are available. The assumption utilized to develop Table 5 is that the average yearly effectiveness is one-half of the initial benefit achieved as a result of a tune-up.

---

[1] The "adequacy" of a mechanic training program will, for the present, be determined on a case-by-case basis. Guidelines will be issued in the future if found to be feasible.

5. *Basic program requirements.* There are two basic types of operation which may be utilized for an I/M program, namely a centralized inspection system (government or contractor operated) and a decentralized inspection system (private commercial garages). In order to obtain full emission reduction benefits for either a centralized or decentralized inspection system, certain minimum requirements are established, which if not met, will result in assessed emission reductions lower than those listed in Tables 1 through 5 of this Appendix.

a. *Program requirements—Minimum* for all programs.

i. Provisions for regular periodic inspection (at least annually) of all vehicles for which emissions reductions are claimed.

ii. Provisions to ensure that failed vehicles receive the maintenance necessary to achieve compliance with the inspection standards. The basic method is to require that failing vehicles pass a retest following maintenance.

iii. Provisions for quality control. The reliability of the inspection system and equipment accuracy must be ensured. This will include routine maintenance, calibration and inspection of all I/M equipment, and routine auditing of inspection results.

b. *Minimum decentralized program requirements.* In order to receive the basic emission reduction benefits for a decentralized I/M program, the following requirements must be included in addition to provisions listed in Section 5(a).

i. Provisions for the licensing of inspection facilities which insure that the facility has obtained, prior to licensing, analytical instrumentation which has been approved for use by the appropriate governing agency. A representative of the facility must have received instructions in the proper use of the instruments and in vehicle testing methods. The facility must agree to maintain records, to collect signatures of operators whose vehicles have passed inspection, and to submit to inspection of the facility.

ii. Records required to be maintained should include the description (make, year, license number, etc.) of each vehicle inspected, and its emissions test results. Records must also be maintained on the calibration of testing equipment.

iii. Copies of these inspection records should be submitted on a periodic basis to the governing agency for auditing.

iv. The governing agency should inspect each facility at least once every 90 days to check the facilities' records, check the calibration of the testing equipment and observe that proper test procedures are followed.

v. The governing agency should have an effective program of unannounced/unscheduled inspections both as a routine measure and as a complaint investigation measure. It is also recommended that such inspections be used to check the correlation of instrument readings among inspection facilities.

c. *Motorcycle and heavy duty truck program requirements.* An acceptable I/M program for motorcycles and trucks must include the same provision specified in Section 5 for light duty vehicles. In addition, a source surveillance program, such as discussed in Section 6(c) is strongly recommended for any emission reduction estimates for motorcycles and heavy duty vehicles. The test procedures and program design for the evaluation of emission reductions should be reviewed in advance by EPA. The source surveillance program can include an assessment of emission deterioration at the option of a state. Without such an assessment, the assumption will be made that average yearly effectiveness is half of the initial benefit found.

6. *Additional Topics—Emission reductions.*

a. *Idle vs. loaded testing.* Although idle and loaded testing do not necessarily fail a mutally inclusive set of vehicles, latest available data indicate no overall difference in HC and CO emission reductions between the two tests. The available data do indicate that the loaded test can be more effective in reducing emissions than the idle test, but only if mechanics are extensively trained in the proper use of loaded test diagnostic information. For this reason, no additional credit is given for loaded mode testing. The loaded emission test does, however, have the potential to measure oxides of nitrogen from automobile emissions and can therefore be a valuable strategy in areas where there is a defined NOx problem.

b. *Tampering inspection.* Additional annual reductions in emissions can be achieved from a program of tampering inspection, in conjunction with emissions inspection. The amount of reduction credited will be a function of the sophistication and complexity of the tampering inspection and the training of the inspectors. To obtain these reductions there must be inspection and maintenance for tampering along with emission I/M. Any plans for tampering inspection should be reviewed with EPA in advance in order to estimate the potential benefits.

c. *Added benefits—source surveillance program.* It is possible that well designed and managed I/M programs will achieve greater reductions than those estimated in this Appendix. This can occur because deterioration rates and other factors may be different for specific geographic areas or because the service industry is doing a better job than estimated or because public maintenance habits improve significantly in response to the program.

To overcome the uncertainty associated with the above it is recommended that a source surveillance program be performed. The results of such a program would allow states and areas to update the emission reduction benefit for I/M as data become available. Such source surveillance studies can determine three key pieces of information: the initial reduction which vehicles can achieve in the first year of a program as a result of inspection and repair, the change in lifetime vehicle emission deterioration which can be credited to yearly inspections, and an accurate location specific emission inventory prior to I/M implementation.

An I/M program has the potential to change both the first year emission rate and the lifetime deterioration curve. Since a source surveillance program needs to be carefully designed to adequately evaluate benefits attributable to I/M, states are encouraged to review source surveillance study designs with regional EPA offices before beginning such programs. Technical guidance for program design and sizing of test samples will be available from EPA.

In the absence of a source surveillance program, states required to submit transportation control plans must use the estimates contained in this Appendix in the determination of emission reductions from inspection/maintenance programs. In addition, current and projected emission factors supplied by EPA must be used in these determinations, unless substantiating justification for other factors is provided.

At the present time, EPA is looking at the possibility of using short inspection tests to determine both percent emission reduction due to inspection and maintenance, and emission deterioration of vehicles over time. The ability to use short tests to determine percent emission reductions due to maintenance will depend upon the correlation of the short test with the Federal Test Procedure. Additional source surveillance implementation information will become available as current analyses are completed.

d. *Alternative approaches.* Maintenance-oriented programs that employ approaches other than emission testing may be capable of achieving emission reductions for in-use motor vehicles. Such approaches, including mandatory maintenance procedures and engine parameter inspection, will be acceptable only if sufficient data are provided to justify the emission reductions estimated.

e. *Program alterations.* Alternations to program design during the course of an I/M program will be evaluated on a case-by-case basis. Such alternations might include: change from an idle test, after several years of use, to a loaded test; change from annual inspection, after several years of use, to a semiannual inspection.

f. *Cutpoint variations.* For a given stringency factor (which is based on both hydrocarbons and carbon monoxide), individual cutpoints for hydrocarbons and carbon monoxide can be varied in a theoretically infinite number of ways. The reductions given in this Appendix assume that there is a particular relationship between hydrocarbon and carbon monoxide cutpoints. This relationship, though considerably more complex than mentioned here, can be generally stated as, for Technology I vehicles, two carbon monoxide failures for each hydrocarbon failure, and for Technology II vehicles, three carbon monoxide failures for each hydrocarbon failure. It is possible that an area's particular pollution problem may call for I/M cutpoints that result in substantial deviations from the HC/CO relationships implicit in this Appendix. At the State's or local area's request, EPA will review the program's cutpoint structure, and make adjustments to emissions reduction credit as necessary.

g. *High altitudes, California.* All emission reductions estimated in this section are also applicable to high altitude areas and for vehicles equipped for use in California.

h. *Oxides of nitrogen.* It has not been shown that maintenance directed at reducing HC and CO emissions has a significant impact on oxide of nitrogen (NOx) emissions. All available data show very minor increases or decreases in NOx levels. It has already been cited (Section 6(a)) that a loaded test is capable of detecting high NOx emitters. Maintenance procedures and an ensuing control strategy to reduce NOx emissions, based on I/M, are therefore conceivable. To the extent that tampering is directed toward NOx emission controls, a good anti-tampering program can reduce NOx emissions.

ATTACHMENT 1

DESCRIPTION OF THE SIMULATION MODEL

Introduction. Empirical data from ongoing inspection/maintenance (I/M) programs has shown that mandatory inspection and maintenance will result in significant air quality benefits. Increased future benefits are to be expected as such programs become stabilized, i.e., the vehicle population has been subject to I/M requirements during its full lifetime. Currently available data, however, is somewhat limited in its ability to estimate these future benefits quantitatively. For this reason, a mathematical model of the I/M process has been developed, in which available empirical data is utilized to make the model as realistic as possible. This approach was used to derive the estimates of benefit presented in Appendix N. Two groups of vehicles were considered, and these groups of vehicles are designated as Technology I and Technology II. Technology I vehicles include all light-duty vehicles manufactured prior to the 1975 model year that were designed to meet pre-1975 exhaust emission standards. Technology II vehicles include all post-1974 light-duty vehicles that were designed to meet the more stringent 1975 and later emission standards. Samples of vehicles of the two technology levels were input to the model, and were taken as representative of Technology I and Technology II vehicles on a nationwide basis. Please note: all computations in Attachments 1 and 2 are based upon the metric system.

I. *Description of the simulation model of the inspection/maintenance process.* The I/M process as currently conceived in the model consists of the following events:

1. Emission deterioration from existing levels.
2. Inspection lane testing of HC and CO levels using the idle test to detect high FTP emitters (NOx emissions are insignificant at idle, and therefore are not considered in the model).
3. Maintenance or repair (resulting in lower emission levels), if a vehicle fails the inspection.

Each vehicle undergoes this sequence of events throughout its useful life, which is assumed to be nine years, or approximately 160,000 kilometers.

The model compares average FTP emissions in the case where an I/M program is operational, with emissions in the case where no I/M program exists. Benefit is calculated as the percent reduction in FTP emissions from the average level in the no I/M case. FTP emission levels art used to measure benefit since the FTP driving cycle is assumed to be representative of vehicle operation in urban areas. Two types of benefit can be computed: (1) the average benefit over a vehicle's life, and (2) the benefit in a particular year of a vehicle's life. Both types of benefit are dependent upon the vehicle's level of emission control technology and the number of times the vehicle has been subjected to a mandatory inspection program. The average benefit for a population of vehicles in a given calendar year is computed from the individual technology level vehicle benefits given in Appendix N, which are of the second type. The calculation methodology is discussed in a later section of this Appendix.

Issues affecting estimated I/M benefit. Benefit due to I/M depends upon the assumptions used to implement the simulation of the I/M process; that is, the assumptions surrounding the three events identified above. Because the currently available data are limited, assumptions were made regarding some of the issues that logically affect benefit. The model reflects these assumptions, which were based on engineering judgment. The issues and assumptions are discussed below.

Issue 1. Emission levels of vehicles at first inspection.

Concept. Benefit in the first and subsequent inspection years is expected to depend on the emission levels of vehicles at their first inspection. There are two ways in which differences in the first year emission levels could produce significant differences in benefit. First, it is possible that for vehicles of a given age there will be differences in the distribution of emission levels at first inspection from one technology level to another; for example, it might be the case that for one technology level vehicles have either very low or very high emissions at first inspection, whereas for another technology level vehicles have emissions which are clumped closely together around some average value. This situation could possibly result in more benefit for the first technology level case, even if the same percentage of vehicles of each technology level were to fail an inspection, since failures in the first technology level case could result in bigger drops in emissions percentagewise. Second, within a technology level, different emission levels at the time of I/M implementation will naturally exist for different model year vehicles, and it is possible that these absolute numerical differences will result in benefit (or percentage) differences as well.

Assumptions. The first year Appendix N benefits, and indirectly the benefits for each subsequent inspection year, were determined by analyzing the emissions performance of one-year-old cars with and without I/M. Separate benefits were calculated for the Technology I and Technology II cases. Technology I first year benefits were based on emissions data on 180 1973–74 models tested in the FY '73 Emission Factor Program. Technology II first year benefits were based on emissions data on 387 1975 models tested in the FY '74 Emission Factor Program. These vehicles were taken to be representative of the nationwide mix of low altitude non-California one-year-old Technology I and Technology II vehicles, respectively, in terms of mileage and maintenance characteristics. As Appendix N benefit numbers indicate, I/M benefits differ by technology level, at least for CO.

With regard to different first year emission levels that all model year vehicles, regardless of age, obtain the same first year benefits. This assumption is based upon the premise that, for public acceptance reasons, the first year pass/fail cutpoints would differ with age or model year so that all vehicles would experience similar failure rates. Limited data indicate that under this premise, benefits (on a percentage-wise basis) are similar.

Issue 2. Emission deterioration.

Concept. Emission deterioration is the process whereby vehicle emission rates increase over time from the levels at which the vehicles were intended to emit when new. Emission deterioration includes changes in emissions due to normal wear of engine/emission control components as well as changes in emissions due to tampering or poor maintenance.

Assumptions. The deterioration rates used in the model are expressed as a percentage of low mileage average FTP values per year. These percentage rates are assumed to be equal for all vehicles of a given technology level, and are constant over time. Specifically, the rates were taken to be 18 percent per year for HC and 15 percent per year for CO for Technology I vehicles; 21 percent per year for HC and 14 percent per year for CO for technology II vehicles. These rates are based on data from EPA's FY '71 through FY '74 Emission Factor Programs and represent vehicle deterioration under typical owner maintenance practices. For a given pollutant and vehicle, the model considers the FTP rate of deterioration per year (grams/kilometer/year) to be constant over time. Thus, deterioration is modeled as a linear phenomenon. The grams/kilometer/year value is calculated as the overall deterioration rate, (in percent) multiplied by the individual vehicle's first-year emission level. Thus, each vehicle is considered to be an inherently low or high emitter with respect to each pollutant; vehicles which have low emissions when new will continue to have relatively low emissions as they accumulate mileage. Emissions of vehicles in the no I/M case are assumed to deteriorate throughout their useful life until they reach the average levels of pre-controlled cars at 161,000 kilometers (100,000 miles).

Significant percentages of catalytic converter failure may occur with increasing vehicle age and if such a situation does occur, the emission rates will increase sharply in later years; that is, a constant deterioration rate assumption will not be valid. However, the surveillance data currently available to EPA do not cover mileage ranges extensive enough to estimate the frequency and effect of such failures.

The FTP deterioration rate (grams/kilometer/year) is assumed not to be affected by the existence of an I/M program. However, if an I/M program is operational, the deterioration process is not continuous because deterioration is interrupted by annual idle test emissions inspections. If a vehicle fails the idle test, its emissions are assumed to be reduced via maintenance or repair to meet the pre-determined idle test standards. The FTP emissions are assumed to be reduced correspondingly, as determined by regression relationships. Following an I/M repair, the deterioration process continues under the assumption that a vehicle's yearly rate of deterioration (gm/km) is unaffected by the repair that occurred. The implication is that the inherent emissions characteristics of a vehicle cannot be improved via repair. If a vehicle passes the idle test, its emissions are left unchanged for the calculation of the average emission levels (gm/km) following the round of I/M. The deterioration process then continues until the next annual inspection occurs.

The idle test deterioration rate per year (percent CO or ppm HC) is also assumed to be constant over time for each vehicle. Idle test deterioration rates are determined from FTP deterioration rates using the following rationale: The effectiveness of I/M in reducing in-use vehicle emissions as measured over the FTP requires that the short test used in the inspection lane be an accurate predictor of FTP passage or failure. One way to ensure this is to define the idle deterioration rate in terms of the FTP deterioration rate. Currently in the model the assumption is made that FTP emissions can be quantitatively predicted from idle test emissions, and vice versa. The idle deterioration rate for a given vehicle is determined from the FTP deterioration rate and a regression relationship. Based on data over a limited mileage range, the relationships are assumed to be independent of milage and maintenance state.

Issue 3. Short test pass/fail cutpoints.

Concept. The purpose of an inspection/maintenance program is to reduce the emissions of in-use vehicles as measured over the FTP. A short emissions test procedure is intended to provide a practical method (i.e., quick and inexpensive) for identifying high FTP emitting vehicles. The benefit associated with an I/M program is dependent on the methodology used to determine the short test pass/fail cutpoint for each pollutant from year to year. The method of determining initial short test cutpoints has varied in practice from assigning cutpoints that are make/model specific to assigning one set of cutpoints for all light duty vehicles with similar emission control technology. The possibility of changing short test cutpoints to reflect vehicle age is also an important consideration.

Assumptions. The HC and CO cutpoints on which the Appendix N benefits are based are technology level specific. Thus, all vehicles of a given emission control technology (for example, catalyst-equipped cars) are assumed to have the same cutpoints. Cutpoints for the first year of the simulated I/M program were set by first specifying a stringency factor and then analyzing appropriate EPA emission factor data on one-year-old vehicles which were assumed to be representative of the nationwide mix of one-year-old vehicles. The analysis resulted in the determination of idle test pass/fail cutpoints for HC and O which corresponded to the specified stringency factor (ranging from 10 percent to 50 percent). For example, if a 30 percent stringency factor was specified, then HC and CO idle test cutpoints were determined so that approximately 30 percent of all vehicles would fail the idle test at the first inspection assuming that owners did not change their maintenance habits from those typically in effect prior to the implementation of I/M.

The relative stringency factors for HC and CO were determined by assuming that a car emitting at twice the HC FTP standard is equally likely to be failed as a car which is emitting at twice the CO FTP standard. This assumption is only one of an infinite number of ways that relative HC and CO stringency factors could be weighted to achieve the specified overall stringency factor. For example, since more AQCRs exceed ambient oxidant emission standards than exceed ambient CO standards, a car at twice the HC FTP emission standard could be considered equally likely to fail as a car which is at four times the CO FTP standard. The result of the weighting criterion which was applied is that at stringency levels below 30 percent, the large majority of vehicle failures can be attributed to high CO emission levels; even though significant percentages of HC failure are detected at stringency levels of 40 percent and above, HC failure is never as high as CO failure, percentagewise.

One of the model's critical assumptions with regard to cutpoint specification is that the first year cutpoints continue to be used year after year to determine which vehicles will pass or fail the idle test. One implication of the assumption of maintaining constant cutpoints over time is that vehicles can continue to be repaired to meet the same standards year after year, regardless of vehicle age or mileage. In support of this assumption, data from the 1972 and 1973 EPA In-use Compliance Program (IUCP) programs indicate that vehicles can continue to be repaired to FTP levels well below short test levels which represent 50 percent stringency levels.

If service industry repair capability is assumed to be minimal (as in the base case Appendix N credits, where failed vehicles are repaired just to meet the idle test cutpoints), another implication is that the percentage of failed vehicles increases over time to about twice the initial stringency factor if, as the model assumes, significant voluntary owner maintenance does not occur. Data from I/M programs in New Jersey and Chicago indicate that the failure rates of a given model year of vehicles do not increase significantly as vehicles age, even though the same cutpoint is applied. Thus, either considerable voluntary maintenance is occurring or mechanics are repairing vehicles to levels significantly better than the minimum required repair levels.

Issue 4. Service industry repair capability.

Concept. Air quality benefit derived from an I/M program is dependent on the ability of the service industry to perform the repair work necessary to lower emissions. Depending on the level of service industry training, idle emissions could be reduced just to the cutpoints, or well below the cutpoints, potentially resulting in different benefits to air quality.

Assumptions. The base case benefits given in Table 1 of Appendix N assume that the service industry is capable of repairing all failed vehicles exactly to the idle test cutpoints. Then the equivalent FTP levels are computed so that the average urban benefits can be calculated. The model assumes that a vehicle which is failed incorrectly on the idle test does not have its FTP emissions either raised or lowered by the repair process. The model also assumes that a vehicle which fails for one pollutant only will have the other pollutant emissions lowered to the FTP equivalent idle standard in cases where errors of emission occurred.

Additional benefit is predicted if mechanic training is in effect. The model assumes that mechanic training would result in the reduction of emissions of failed vehicles to the FTP standards. As in the base case, the model assumes that if a vehicle fails for one pollutant only, the other pollutant will also be reduced to the FTP standard if an error of emission occurred. The first year credits indicate a dependency on stringency factor. For catalyst vehicles, the tendency is for mechanic training to have the largest effect on programs with stringency factors of 20 and 30 percent. This is reasonable because the effect of mechanic training is jointly dependent on the percent of cars failed and the degree of improvement in the FTP levels of repaired vehicles resulting from the mechanic training program: If only 10 percent of all cars are failed initially, then only 10 percent of all cars are repaired so that even an apparently significant increased reduction due to mechanic training will be somewhat dampened by the fact that a good percentage of the remaining cars are undoubtedly high FTP emitters which simply were not caught. If, on the other hand, 50 percent are failed and the FTP standards in gm/km are approximately equal to the FTP levels corresponding to the more stringent idle test cutpoints additional benefit due to mechanic training would be insignificant. For precatalyst CO, the tendency described above, although less apparent, still seems to be present. However, precatalyst HC exhibits a tendency for mechanic training to have an increasing effect with increasing stringency factor. The tendency is explained by the fact that for the data which were input to the computer program, the HC FTP standards in gm/km was significantly lower than the FTP level corresponding to the idle test HC cutpoint, even at stringencies of 40 to 50 percent. As a result, an increased percentage of failed vehicles continued to produce increased benefit due to mechanic training.

The model assumes that owner tampering following the sequence of events: failure of the idle test, vehicle repair, and subsequent passage of the idle test, does not occur. Since motorists frequently attribute driveability problems to properly-functioning emission control devices, this assumption may be somewhat unrealistic unless mechanics become more knowledgeable about the tradeoffs between performance and emission rates. However, a good estimate of the frequency and effect of owner tampering (either with or without I/M) is not available at the present time. Moreover, the benefit credits given in Appendix N require the existence of an effective anti-tampering program.

Issue 5. Frequency of inspection.

Concept. Since emission deterioration is modeled to occur continuously over time, the frequency of inspection determines the extent of vehicle deterioration between inspections. The more frequent the inspection, the less the vehicles deteriorate and thus the greater the I/M benefit.

Assumptions. For the base case benefits given in Appendix N, inspections are modeled to take place annually. Additional benefits result from semi-annual inspections. The difference in benefits from the annual to the semi-annual case is presented in section 3(c) of Appendix N.

Issue 6. Short test procedure used in the inspection lane.

Concept. Since the intent of an I/M program is to reduce the emissions of in-use vehicles as measured over the FTP, one would ideally be able to design a short emissions test procedure whose results could be used to accurately predict FTP emission levels. From a practical standpoint, the short test procedure must be quick, inexpensive, and applicable to vehicles in a warmed-up condition.

Assumptions. Benefits presented in Appendix N are based on the assumption that the idle test is used in the inspection lane. Limited analysis using the simulation model indicates that benefits using the idle test and a loaded test are comparable since the two tests are equally able to identify high FTP emitters.

ATTACHMENT 2

METHODOLOGY FOR APPLYING APPENDIX N BENEFIT NUMBERS

Tables 1 and 2 of Appendix N provide the I/M benefit numbers necessary to calculate the estimated calendar year percent reduction in HC and CO emissions from emission levels expected in the absence of I/M. To determine the percent reduction in HC and CO emissions for a given calender year, the Appendix N numbers must be applied to the scenario in question. The scenario is specified in determining the following for the calendar year i of interest;

1. The calendar year, y, in which an I/M program was implemented.
2. The number or percentage of vehicles of each model year ($i-12$ through i) contributing to the total vehicle population (vehicles of model years earlier than $i-12$ should be considered as model year $i-12$).
3. Average vehicle kilometers traveled by each model year group of vehicles.
4. HC and CO emission factors (grams/kilometer) for each model year group of vehicles, assuming I/M has never been in effect.

The calculation of emission reduction in kilograms for a given pollutant (HC or CO) in calender year i is performed as follows:

$$D_i = \sum_{t=i-12}^{i} b_{it} e_{it} m_{it} n_{it},$$

where

b_{it} = percent reduction in emissions for vehicles of model year t in calendar year i.[2]

e_{it} = emission factor (grams/kilometer) for vehicles of model year t in calendar year i, assuming I/M has never been in effect.

m_{it} = average kilometers traveled by vehicles of model year t in calendar year i.

n_{it} = number of vehicles of model year t in calendar year i.

The calculation of benefits in percent, B_i, in calendar year i requires one further step:

$$B_i = 100\, D_i \Big/ \left(\sum_{t=i-12}^{i} e_{it} m_{it} n_{it} \right).$$

where the definitions of m, n, and e are as above.

If only the percent reduction is of interest, rather than the kilograms, the following alternative calculation of B_i can be used:

$$B_i = 100 \frac{\sum_{t=i-12}^{i} b_{it} e_{it} m_{it} p_{it}}{\sum_{t=i-12}^{i} e_{it} m_{it} p_{it}}.$$

where b, e, and m, are defined as above, and p is the fraction of vehicles on the road in calendar year i which are of model year t.

The calculation of the scenario's reduced emission factor (grams/kilometer) in calen-

---

[2] The benefit numbers in Tables 1 through 4 of Appendix N (which represent both the base case of I/M and the case where mechanic training and/or a semi-annual program is in effect), can be used to determine b_{it} by identifying the technology level represented by vehicles of model year t and the number of inspections which vehicles of model year t have undergone by the beginning of calendar year i. The number of inspections can be calculated formally as the minimum of $(i-y)$ and $(i-t)$ for an annual I/M program, where i is the calendar year of interest, y is the year in which I/M was implemented, and t is the model year. It is assumed that the maximum number of annual inspections for vehicles of all model years will be eight. For purposes of calculating benefit, model year vehicles which have undergone more than eight inspections should be treated as if only eight have been undergone.

Reproduced from best available copy.

dar year t as a result of I/M, is performed as follows:

$$(BF)_t=\frac{(100-B_t)}{100}\cdot\left(\sum_{i=t-12}^{t} e_{it}m_{it}n_{it}\right)\Big/\left(\sum_{i=t-12}^{t} m_{it}n_{it}\right),$$

where B_t, e_{it}, m_{it}, and n_{it} are as defined above. (Replacement of n_{it} with p_{it} will yield the same numerical results).

Appendix N can also be used to compute the average percentage benefit of I/M for a given vehicle over its useful life, which is assumed to be nine years or approximately 160,000 kilometers and represents eight annual I/M inspections. If the vehicle is of model year t and I/M began in calendar year y, this percent reduction in emissions for a specific pollutant is computed as follows:

$$U_t=100\cdot\left(\sum_{k=t}^{t+8} b_{k,t}e_{k,t}m_{k,t}\right)\Big/\left(\sum_{k=t}^{t+8} e_{k,t}m_{k,t}\right),$$

where

k=calendar years covering the useful life of a vehicle of model year t; $k=t, t+1, \cdots, t+8$,
$b_{k,t}$=percent reduction in emissions for vehicles of model year t in calendar year k,[3]
$e_{k,t}$=emission factor (grams/kilometer) for vehicles of model year t in calendar year k, assuming I/M has never been in effect.
$m_{k,t}$=average kilometers traveled by vehicles of model year t in calendar year k.

Nationwide estimates of the number of vehicles of each model year in the calendar year of interest, and average kilometers traveled by each model year vehicle for the calendar year of interest can be obtained by referring Table 1 which provides nationwide estimates of number of vehicles by vehicle age, and average kilometers traveled by vehicle age. Nationwide estimates of emission factors by calendar year are available in AP–42. Tables 2 and 3 provide, for illustrative purposes only, sample emission factors for calendar years 1977–1980 in format to be utilized in the upcoming revision of AP–42, Supplement 5.

Examples of the application of the methodology for calculating benefit.

Specification of scenario for problem examples 1 and 2. The nationwide mix of vehicles by age and average VKTs, as given in AP–42, applies. An I/M program with a 40 percent stringency factor was implemented in 1973, and vehicles one-year-old or older were tested by the end of calendar year 1973.

Problem 1. Determine the present reduction in emissions for HC and CO in CY 1977, assuming that the I/M inspections are annual, and that no mechanic training program is in effect.

Solution. The percent reduction, B_{77}, can be calculated from the formula:

$$B_{77}=\frac{\sum_{t=77-12}^{77} b_{77,t}e_{77,t}m_{77,t}p_{77,t}}{\sum_{t=77-12}^{77} e_{77,t}m_{77,t}p_{77,t}}\times 100,$$

where

$b_{77,t}$=percent reduction in emissions for vehicles of model year t in calendar year 1977 (obtained from Appendix N),
$e_{77,t}$=emission factor (gm/km) for vehicles of model year t in calendar year 1977, assuming I/M has never been in effect (obtained from AP–42),
$m_{77,t}$=average kilometers traveled by vehicles of model year t in calendar year 1977 (obtained from AP–42)
$p_{77,t}$=fraction of total vehicles on the the road in calendar year 1977 which are of model year t (obtained from AP–42).

Note that the denominator of B_{77} is the usual AP–42 type calculation of emission factors.

The following tables detail the calculation of both the numerator and denominator of B_{77} for HC and CO:

t	$b_{77,t}$ (percent)	$e_{77,t}$	$m_{77,t}$	$p_{77,t}$	Numerator product	Denominator product
1977	0	0.9	25.6	0.081	0	1.86
1976	16	1.1	24.2	.110	.47	2.93
1975	23	1.2	22.5	.107	.66	2.89
1974	24	2.9	21.1	.106	1.56	6.45
1973	30	3.4	19.6	.102	2.04	6.80
HC 1972	30	3.7	18.2	.096	1.94	6.46
1971	30	4.1	16.6	.088	1.80	5.99
1970	30	4.5	15.1	.077	1.57	5.23
1969	30	4.9	12.7	.064	1.29	4.30
1968	30	5.3	12.2	.049	.95	3.17
Pre-1968	30	6.1	10.8	.120	2.37	7.96
					14.65	54.07

HC: $B_{77}=(14.7/54.1)\times 1.00=.27$.

t	$b_{77,t}$ (percent)	$e_{77,t}$	$m_{77,t}$	$p_{77,t}$	Numerator product	Denominator product
1977	0	14.7	25.6	0.081	0	30.5
1976	33	16.6	24.2	.110	14.6	44.2
1975	41	18.6	22.5	.107	18.4	44.8
1974	34	35.3	21.1	.106	26.8	78.9
1973	38	39.5	19.6	.102	30.0	79.0
CO 1972	38	43.7	18.2	.096	29.0	76.3
1971	38	47.9	16.6	.088	26.6	70.0
1970	38	52.1	15.1	.077	23.0	60.6
1969	38	56.3	13.7	.064	18.8	49.4
1968	38	60.5	12.2	.049	13.7	36.2
Pre-1968	38	77.5	10.8	.120	38.2	100.4
					239.1	670.3

CO: $B_{77}=(239.1/670.3)\times 1.00=.36$.

Problem 2. Determine the percent reduction in emissions, B_{77}, for HC and CO in CY 1977, assuming that the inspections are annual and that an adequate mechanic training program is in effect.

Solution. The method used for Problem 1 applies. Only the $b_{77,t}$ numbers will differ to reflect the presence of an adequate program of mechanic training. The following tables detail the calculation of both numerator and denominator of B_{77} for HC and CO:

t	$b_{77,t}$ (percent)	$e_{77,t}$	$m_{77,t}$	$p_{77,t}$	Numerator product	Denominator product
1977	0	0.9	25.6	0.081	0	1.87
1976	17	1.1	24.2	.110	.50	2.93
1975	25	1.2	22.5	.107	.72	2.89
1974	35	2.9	21.1	.106	2.27	6.49
1973	41	3.4	19.6	.102	2.79	6.80
HC 1972	41	3.7	18.2	.096	2.65	6.46
1971	41	4.1	16.6	.088	2.46	5.99
1970	41	4.5	15.1	.077	2.15	5.23
1969	41	4.9	12.7	.064	1.76	4.30
1968	41	5.3	12.2	.049	1.30	3.17
Pre-1968	41	6.1	10.8	.120	3.24	7.91
					19.84	54.04

HC: $B_{77}=(19.8/54.0)\times 1.00=.37$.

t	$b_{77,t}$ (percent)	$e_{77,t}$	$m_{77,t}$	$p_{77,t}$	Numerator product	Denominator product
1977	0	14.7	25.6	0.081	0	30.5
1976	40	16.6	24.2	.110	17.7	44.2
1975	51	18.6	22.5	.107	22.8	44.8
1974	47	35.3	21.1	.106	37.1	78.9
1973	51	39.5	19.6	.102	40.3	79
CO 1972	51	43.7	18.2	.096	38.9	76.3
1971	51	47.9	16.6	.088	35.7	70
1970	51	52.1	15.1	.077	30.9	60.6
1969	51	56.3	13.7	.064	25.2	49.4
1968	51	60.5	12.2	.049	18.5	36.2
Pre-1968	51	77.5	10.8	.120	51.2	100.4
					318.3	670.3

CO: $B_{77}=(318.3/670.3)\times 1.00=.48$.

Specification of scenario for problem example 3. The nationwide mix of vehicles by age and average VKT, as given in AP–42, applies. An I/M program with a 30% stringency factor was implemented in calendar year 1980, and vehicles one year old or older were tested by the end of calendar year 1980. The program is annual and no mechanic training program is in effect. Since the emissions characteristics of 1978 and later model year cars are unknown, it will be assumed that the initial year emissions from these vehicles will be the same as that determined for 1975 model year vehicles by the Agency's Emission Factor Program; namely, .87 gm./km. HC and 14.7 gm./km. CO. Also, it will be assumed that 1978 and later model year vehicles deteriorate at the same rate as 1975–77 models; namely, .17 gm/km./yr. HC and 1.95 gm./km./yr. CO.

Problem 3. Determine the percent reduction in emissions, B_{90}, for HC and CO in calendar year 1990, and the resulting reduced emission factors for HC and CO for calendar year 1990.

Solution. To calculate B_{90}, the method used in the solutions to Problems 1 and 2 applies. The following tables detail the numerical calculation of both numerator and denominator of B_{90} for HC and CO.

t	$b_{90,t}$ (percent)	$e_{90,t}$	$m_{90,t}$	$p_{90,t}$	Numerator product	Denominator product
1990	0	0.9	25.6	0.081	0	1.87
1989	9	1.1	24.2	.110	.26	2.93
1988	16	1.2	22.5	.107	.46	2.89
1987	23	1.4	21.1	.106	.72	3.13
1986	29	1.6	19.6	.102	.93	3.20
1985	34	1.7	18.2	.096	1.01	2.97
HC 1984	39	1.9	16.6	.088	1.08	2.78
1983	42	2.0	15.1	.077	.98	2.32
1982	45	2.2	12.7	.064	.88	1.93
1981	45	2.4	12.2	.049	.65	1.44
1980	45	2.4	10.8	.033	.38	.86
Pre-1980	45	2.4	10.8	.087	1.01	2.26
					8.24	28.56

HC: $B_{90}=(8.2/28.6)\times 1.00=.29$.

t	$b_{90,t}$ (percent)	$e_{90,t}$	$m_{90,t}$	$p_{90,t}$	Numerator product	Denominator product
1990	0	14.7	25.6	0.081	0	30.5
1989	28	16.6	24.2	.110	12.4	44.2
1988	36	18.6	22.5	.107	16.1	44.8
1987	43	20.6	21.1	.106	19.8	46.1
1986	47	22.5	19.6	.102	21.1	45.0
1985	51	24.5	18.2	.096	21.8	42.8
CO 1984	55	26.4	16.6	.088	21.2	38.6
1983	58	28.4	15.1	.077	19.2	33.0
1982	63	30.3	12.7	.064	16.7	26.6
1981	63	32.3	12.2	.049	12.2	19.3
1980	63	32.3	10.8	.033	7.3	11.5
Pre-1980	63	32.3	10.8	.087	19.1	30.3
					186.9	412.7

CO: $B_{90}=(186.9/412.7)\times 1.00=.45$.

---

[3] The benefit numbers in Tables 1 through 4 of Appendix N (which represent both the base case of I/M and the case where mechanic training and/or a semi-annual program is in effect), can be used to determine $b_{k,t}$, by identifying the technology level represented by vehicles of model year t and the number of inspections which vehicles of model year t have undergone by the beginning of calendar year k. The number of inspections (for calendar years after calendar year y) can be calculated formally as the minimum of $(k-y)$ and $(k-t)$ for an annual I/M program, where y is the year in which I/M was implemented, t is the model year, and k is the calendar year. Note that $b_{k,t}=0$ for k less than or equal to y.

To calculate the reduced emission factors for HC and CO, the following formula can be used:

$$(EF)_{80}=\frac{100-B_{80}}{100}\times\frac{\sum_{t=80-12}^{80} e_{80,t}\,m_{80,t}\,p_{80,t}}{\sum_{t=80-12}^{80} m_{80,t}\,p_{80,t}}$$

The following tables detail the calculation of the numerator and denominator:

t	$e_{80,t}$	$m_{80,t}$	$p_{80,t}$	Numerator product	Denominator product
1980	0.9	25.6	0.081	2.07	1.87
1979	1.1	24.2	.110	2.93	2.66
1978	1.3	22.5	.107	2.80	2.41
1977	1.4	21.1	.106	3.13	2.24
1976	1.6	19.6	.102	3.20	2.00
1975	1.7	18.2	.096	2.97	1.75
HC 1974	1.9	16.6	.088	2.78	1.46
1973	2.0	15.1	.077	2.32	1.16
1972	2.2	13.7	.064	1.98	.88
1971	2.4	12.2	.049	1.43	.60
1970	2.4	10.8	.033	.86	.36
Pre-1970	2.4	10.8	.087	2.25	.94
				25.78	18.33

HC: $(EF)_{80}=.71\times\frac{25.8}{18.3}=1.12$ g/km.

t	$e_{80,t}$	$m_{80,t}$	$p_{80,t}$	Numerator product	Denominator product
1980	14.7	25.6	0.081	30.5	2.07
1979	16.6	24.2	.110	44.2	2.66
1978	18.6	22.5	.107	44.8	2.41
1977	20.6	21.1	.106	46.1	2.24
1976	22.5	19.6	.102	45.0	2.00
1975	24.5	18.2	.096	42.8	1.46
CO 1974	28.4	16.6	.088	35.6	1.46
1973	28.4	15.1	.077	33.0	1.16
1972	30.3	13.7	.064	26.6	.88
1971	32.3	12.2	.049	19.3	.60
1970	32.3	10.8	.033	11.5	.36
Pre-1970	32.3	10.8	.087	30.3	.94
				412.7	18.24

CO: $(EF)_{80}=.55\times\frac{412.7}{18.2}=12.5$ g/km.

TABLE 1.—*Estimated fraction of vehicles in use nationwide and average annual kilometers driven nationwide, by vehicle age*

Vehicle age, in years	Fraction of vehicles	Average annual kilometers driven, in thousands
1	0.081	25.6
2	.110	24.2
3	.107	22.5
4	.106	21.1
5	.102	19.6
6	.096	18.2
7	.088	16.6
8	.077	15.1
9	.064	13.7
10	.049	12.2
11	.033	10.8
12+	.087	10.8

Source: AP-42.

TABLE 2.—*Emission factors for light-duty, gasoline-powered vehicles (automobiles) (low altitude, non-California)*

Model year	Carbon monoxide, grams/kilometer, calendar year—			
	1977	1978	1979	1980
Pre-1968	77.5	77.5	77.5	77.5
1968	60.5	60.5	60.5	60.5
1969	56.3	60.5	60.5	60.5
1970	52.1	56.3	60.5	60.5
1971	47.9	52.1	56.3	56.3
1972	43.7	47.9	52.1	56.3
1973	39.5	43.7	47.9	52.1
1974	25.3	22.5	43.7	47.9
1975	18.6	20.6	22.5	24.5
1976	16.6	18.6	20.6	22.5
1977	14.7	16.6	18.6	20.6

TABLE 3.—*Emission factors for light-duty, gasoline-powered vehicles (automobiles) (low altitude, non-California)*

Model year	Hydrocarbons, grams per kilometer; calendar year			
	1977	1978	1979	1980
Pre-1968	6.1	6.1	6.1	6.1
1968	5.3	5.3	5.3	5.3
1969	4.9	5.3	5.3	5.3
1970	4.5	4.9	5.3	5.3
1971	4.1	4.5	4.9	5.3
1972	3.7	4.1	4.5	4.9
1973	3.4	3.7	4.1	4.5
1974	2.9	3.4	3.7	4.1
1975	1.2	1.4	1.6	1.6
1976	1.1	1.2	1.4	1.6
1977	.9	1.1	1.2	1.4

[FR Doc.77-12296 Filed 4-29-77;8:45 am]

FEDERAL COMMUNICATIONS COMMISSION

[47 CFR Part 73]

[Docket No. 21205; RM-2781]

TV BROADCAST STATION IN LIHUE, HAWAII

Proposed Change in Table of Assignments

AGENCY: Federal Communications Commission.

ACTION: Proposed rule making.

SUMMARY: Notice of Proposed Rule Making is issued in response to petition for educational television channel in Lihue (Kauai) Hawaii.

DATES: Comments must be received on or before May 31, 1977, and reply comments must be received on or before June 21, 1977.

ADDRESSES: Send comments to: Federal Communications Commission, Washington, D.C. 20554.

FOR FURTHER INFORMATION CONTACT:

Stanley Schmulewitz, Policy and Rules Division, Broadcast Bureau (202-632-9660).

SUPPLEMENTARY INFORMATION:

Adopted: April 15, 1977.

Released: April 22, 1977.

In the matter of amendment of § 73.606(b), table of assignments, television broadcast stations (Lihue (Kauai), Hawaii).

1. The Commission, by the Chief, Broadcast Bureau, has before it for consideration a petition for rule making filed by the Hawaii Public Broadcasting Authority ("Authority"). The petition seeks amendment of Section 73.606(b) of the Commission's Rules, the Television Table of Assignments, by assigning Channel 67 to Lihue (Kauai), Hawaii and reserving it for noncommercial educational use.

2. We are told that the Authority is an agency created by an Act of the state legislature of Hawaii for the purpose of making educational television available to the citizens of Hawaii on a coordinated state-wide basis. In pursuance of its statutory mandate, the Authority operates noncommercial educational Station KHET, Channel 11, Honolulu, and noncommercial educational Station KMEB, Channel 10, Wailuku, which operates as a satellite of Station KHET. In addition, the Authority is operating or plans to operate a series of translator facilities which it believes to be the most efficient, cost-effective method of spreading public television to the less populated areas of the Hawaiian Islands.

3. The objective here is to be able to serve the area of Lihue, Kauai Island, with a one kilowatt translator on Channel 67.[1] This channel is requested although Channels 21 and 27 are already allocated to the community and reserved for educational use. The reason given by the Authority for the request is that virtually all receiving antennas on the Island of Kauai are designed for Channels 55 and above. This appears to be borne out by existing translator licenses on Channels 70, 74, 76 and 78 in Lihue.

4. Lihue (pop. 3,124) is located on the Island of Kauai (pop. 27,761), the westernmost of the principal Hawaiian Islands and is approximately 160 kilometers (100 miles) northwest of Honolulu. The proposed assignment meets all spacing requirements and would allow improved educational television service on the Island of Kauai. Other channels

---

[1] Pursuant to paragraph 4 of the *Report and Order* in Docket No. 18861, 36 FR 19586, 23 R.R. 2d 1504 (1971), high-powered UHF translators such as this may be operated only on unoccupied channels which are listed in the Television Table of Assignments. See also §§ 74.702(g) and 74.735(e) of the rules.

Appendix D

LOADED-MODE TRUTH CHART AND DIAGNOSTIC PROCEDURES

Appendix D

LOADED-MODE TRUTH CHART AND DIAGNOSTIC PROCEDURES

D.1 TRUTH CHART USAGE

The truth chart (Table D-1) shows failure patterns resulting from various types of malfunction or maladjustment. Also shown on the truth chart is a general description of the probable cause of failure and diagnostic code for each failure pattern.

The test results of failed vehicles are compared with the truth chart to determine the correct failure pattern. The inspector then determines the general cause of failure and refers to the appropriate diagnostic procedures, as indicated by the diagnostic code, for a more detailed analysis of the problem.

Example: A vehicle fails HC and CO in the idle-mode. The inspector uses the truth chart and finds the correct failure pattern. The probable cause of failure, in this case, is the idle air/fuel mixture is too rich, the diagnostic code is 1. This portion of the diagnostic truth table is shown below.

	IDLE	LOW	HIGH	COMMENTS/PROBABLE CAUSE OF FAILURE	DIAGNOSTIC CODE
CO	F	Ⓕ			
HC	Ⓕ			Idle air/fuel mixture rich	1

The inspector refers to diagnostic procedure 1 and finds that a rich air/fuel mixture at idle may be caused by one or more of the following:

Preceding page blank

Table D-1. DIAGNOSTIC TRUTH CHART

	TEST MODE				
	Idle	Low	High	COMMENTS/PROBABLE CAUSE OF FAILURE	DIAGNOSTIC CODE
NO_x		F[a]	F[b]	Faulty ignition advance and/or EGR.	6
CO	F	Ⓕ			
HC	Ⓕ			Idle air/fuel mixture rich.	1
HC	F			HC emission fluctuate.	
CO	N/L			CO emission normal or low.	2
				Idle air/fuel mixture lean.	
	Ⓕ	F	F		
CO	Ⓕ		F	Faulty carburetion or air induction	3
	Ⓕ	F		system.	
	Ⓕ	F		Faulty spark plug(s), spark plug	
HC	Ⓕ	F	F	wire(s), or ignition components.	4
	Ⓕ		F		
HC	Ⓕ	F	F		
CO	Ⓕ	F	F	Faulty exhaust valve action and/or faulty rings.	5

[a] 1971 through 1974 model LDV.

[b] 1975 and later model LDV.

F = Mode must fail.

Ⓕ = Mode may also fail.

- Faulty idle mixture adjustment
- PDV restriction
- Faulty air injection system (if equipped)
- Clogged carburetor idle air-bleed passages.

In addition, diagnostic procedures for determining which of the above case causing the failure are listed. The diagnostic procedures are to be completed in the order shown. This will help to insure that the simplest, quickest and least costly repair will be found to resolve the problem. The repairs are then performed per the manufacturer's specifications.

Diagnostic Procedure 1 - Idle A/F Mixture Rich

The following procedures are to be completed in the order shown. Refer to service manuals for specific repair information.

Diagnosis

Rich A/F mixture at only idle can be caused by PCV restriction, faulty idle mixture adjustment, air inspection (if equipped), or clogged carburetor idle air-bleed passages. Rich idle A/F mixture causes failing CO and high, possible failing HC emission at idle. Since this malfunction occurs only at idle, the air cleaner, carburetor choke, and carburetor mainsystems are satisfactory.

A. Carburetor Idle Adjustment - Make a gross adjustment of idle mixture to determine whether CO can be brought within the specification. If CO can be corrected by adjustment, complete the final adjustments. If not, continue with diagnosis.

B. PCV System - Test PCV valve by disconnecting tube to crankcase and feeling for vacuum ahead of the valve at idle. Replace valve if vacuum cannot be detected. Check all components for free flow. Listen for clicking of valve to changes in vacuum.

C. Air Injection System (if equipped) - Disconnect from air injection pump. Feel for pressure and flow. If no flow can be detected, service pump.

D. Clogged Idle Air-Bleed Passages - If CO cannot be corrected by one of the above, carburetor must be rebuilt.

Diagnostic Procedure 2 - Idle A/F Mixture Lean

Diagnosis

Lean idle A/F mixture can be caused by excessive air leaking into the engine at idle or too lean an idle screw adjustment. Lean A/F mixture results in normal or low CO emissions (may be less than 1 percent) and high fluctuating HC emissions. High HC emissions can also be caused by grossly advanced ignition timing.

A. Gross Lean Adjustment of Idle Mixture - If idle CO emissions are less than 0.5 percent, richen idle mixture to determine if HC emissions can be brought within specification. If they can, then perform ADJUSTMENT.

B. Vacuum Leak - Inspect for vacuum leaks in the induction system by spraying a heavy hydrocarbon onto the carburetor body and intake manifold. Idle speed will increase and engine idle will smooth out if vacuum leaks are present. Check for loose or missing vacuum hoses. Check PCV ventilation valve to determine if it is stuck in full flow position.

C. Ignition Timing - Check timing and advance with timing light. Check dwell with oscilloscope.

Diagnostic Procedure 3 - Faulty Carburetion

Diagnosis

Faulty carburetion results in excessive carbon monoxide emissions during low and high cruise and may contribute to excessive idle emissions. Faulty carburetion causes excessive quantities to fuel to be supplied to the engine. It may also be due to problems with the air induction system rather than the carburetor itself.

A. Air Cleaner - Inspect air cleaner element. Replace if CO emissions at 2,500 rpm with and without air cleaner element installed change more than 1 percent CO.

B. Carburetor Choke - Check to ensure that the choke is not stuck partially closed. Repair or adjust if not fully open at normal engine temperature.

C. Carburetor Main System - With air cleaner removed and choke open, measure CO emissions at 2,500 rpm. Carburetor main system is satisfactory if CO emissions decrease to less than one half of idle CO emission level.

D. Fuel Pump Pressure - Check for excess fuel pressure. If excess pressure is present, check for restricted fuel return line and pump bypass valve.

Diagnostic Procedure 4 - Faulty Spark Plug, Spark Plug Wire, or Ignition Components

Diagnosis

Spark plug, spark plub wire or ignition component failures resulted in secondary ignition misfire in at least one cylinder producing very high HC emissions during low and high cruise and may contribute to high idle emissions.

A. Conduct an ignition system diagnosis. Check for erroded plugs, incorrect gap, disconnected or open wires, crossfire, distributor cap and rotor condition.

B. Conduct a diagnosis of the following components to determine where the expected fault is occurring; coil, condensor, distributor advance mechanisms, electronic ignition components.

Diagnostic Procedure 5 - Faulty Exhaust Valve Action/Bad Rings

Diagnosis

Faulty exhaust valve action and/or bad rings result in producing high HC and CO emissoins in low and/or high cruise. This condition may also cause high HC and/or CO emissions in the idle-mode.

A. Conduct a compression check to determine if the valve(s) are seating. The compression check should show no more than 20 percent variation from highest to lowest cylinder and be within the manufacturer's recommended specification.

B. If the compression check is not satisfactory, perform a cylinder leak down test to determine whether the rings or valves are at fault.

Diagnostic Procedure 6 - Faulty Ignition Advance and/or EGR

Diagnosis

On NO_x system equipped vehicles, either original equipment or retrofit equipment, the ignition advance is modified to inhibit NO_x formation. Many vehicles also employ exhaust gas recirculation (EGR). These systems may malfunction resulting in excessive NO_x emissions during the low or high cruise.

A. Determine whether emission failure is due to NO_x system malfunction. Repair or replace the system according to applicable service procedures. Check for plugged EGR valves or disconnected hoses.

B. Check for vacuum or mechanical advance malfunction, incorrect basic timing or dwell. Repair and adjustment of the timing malfunction may correct the NO_x failure.

Appendix E

SHORT TEST EMISSIONS STANDARDS AS RELATED TO FEDERAL TEST PROCEDURE (FTP)

Appendix E

SHORT TEST EMISSIONS STANDARDS AS RELATED TO FEDERAL TEST PROCEDURE (FTP)

E.1 SHORT TEST CORRELATION

The correlation attributes between short test programs and FTP tests for noted gaseous emissions for model year 1975 are presented in Figures E-1, E-2, E-3, E-4, E-5, and E-6. In setting pass fail limits in a mandatory inspection program using modal testing, it is required to set concentration standards that relate in a logical manner to the Federal Constant Volume Sampling (CVS) test procedure.

U.S. Environmental Protection Agency (EPA) report "Evaluation of Restorative Maintenance on 1975 and 1976 Light-duty Vehicles in Detroit, Michigan" (Ref. 10) presented emission test results for individual vehicles for test types noted in Table E-1. This data is plotted in the graphs as noted above for idle and loaded mode. The data, along with its statistical analysis, indicates a low level of correlation. Superimposed on the graph is a Federal Test Procedure to short test procedure regression relationship established by the EPA (Williams, 76). To establish a starting point for any one level of gr/mile as required by the Federal registration, one would read of the FTP Reading and project this to regression line and proceed to read the corresponding ppm reading. This is only a starting point to establish the promulgated regulation ppm reading under Michigan law for a short-test operation. It is evident that this is a very rough approximation because of the lack of correlation of data points as plotted with respect to FTP test requirements.

Preceding page blank

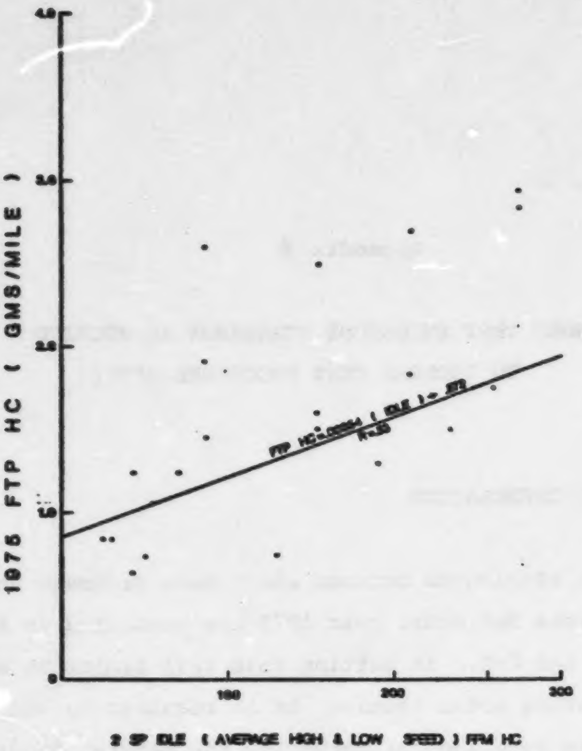


Fig. E-1
HC Emissions
Idle Mode

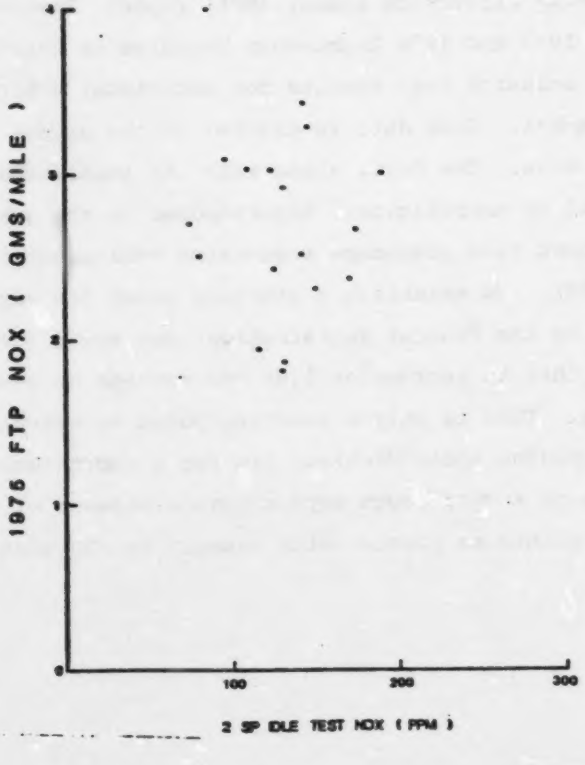


Fig. E-2
NO_x Emissions
Idle Mode

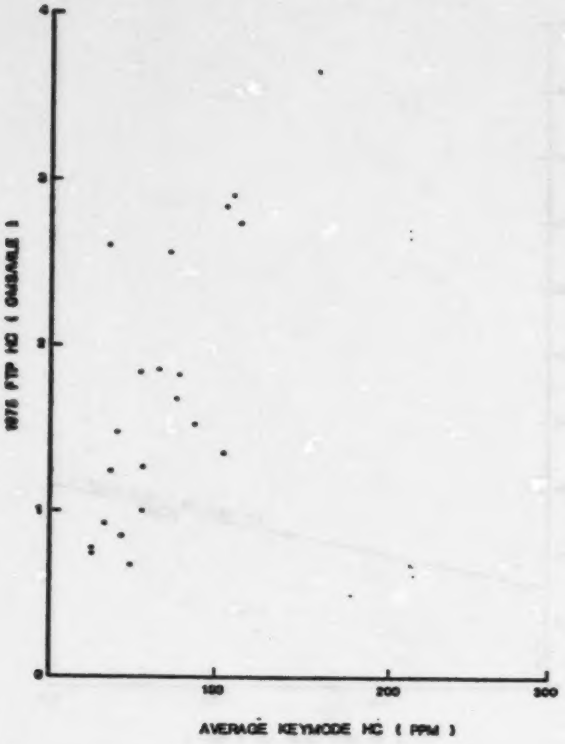


Fig. E-3
HC Emissions
Key Mode

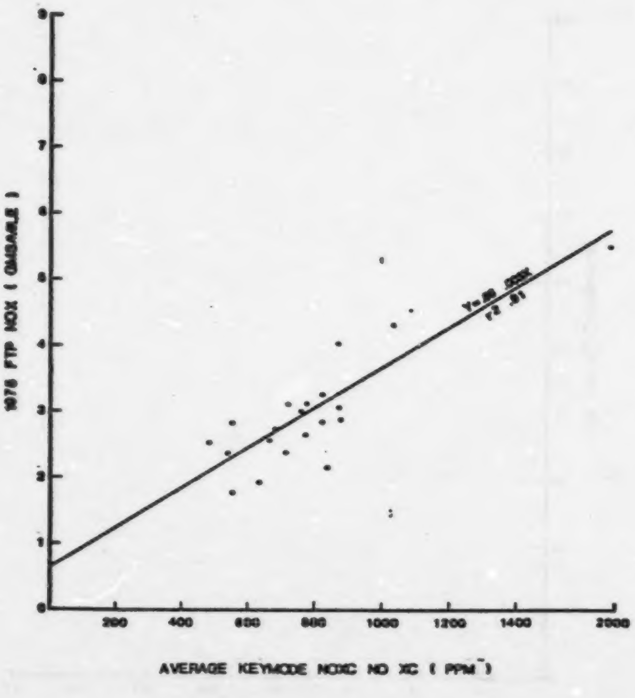


Fig. E-4
NO_x Emissions
Key Mode

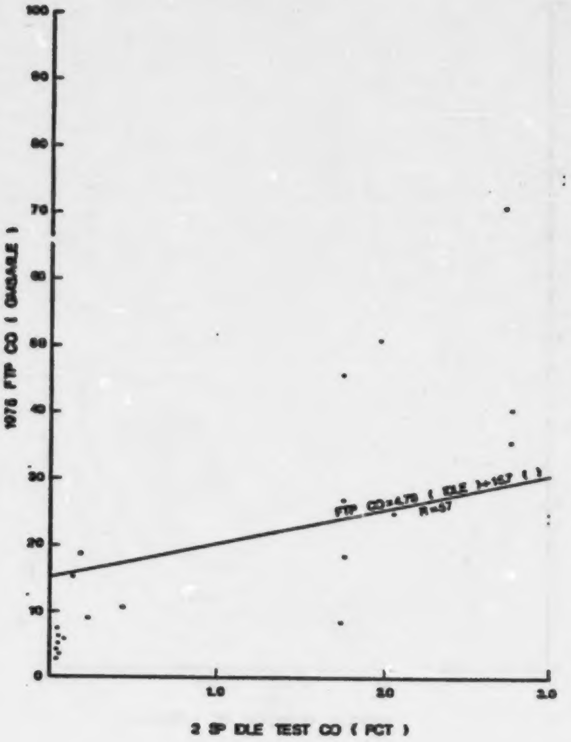


Fig. E-5
CO Emissions
Idle Mode

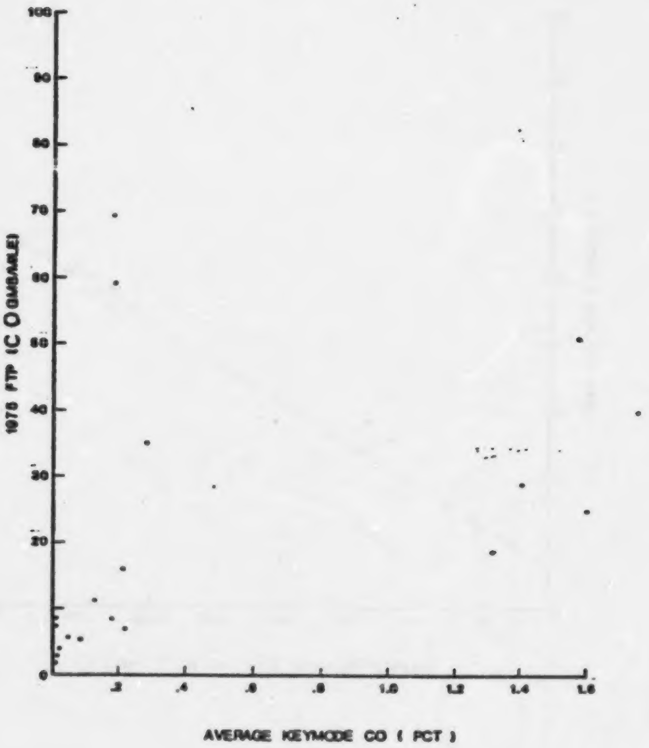


Fig. E-6
CO Emissions
Key Mode

Table E-1. TEST TYPES

TEST	EMISSIONS READINGS	TEST PROCEDURE CHARACTERISTICS
1975 FTP	GMS/Mile	Defined in sections 85.076-14 through 85.075.24 of Federal Register Vol. 37, No. 221
HWY FET	GMS/Mile	Defined driving cycle of 10.2 miles and 765 second duration
FED SCY	GMS/Mile	Driving cycle of 125 second duration and .7536 miles in length and 9 modes
NY/NJ	GMS/Mile	Driving cycle of 75 seconds duration and .2792 miles in length consisting of 7 mode
KEY MODE	Concentration ppm/pct	3 Steady-state operating conditions high-speed, low speed and idle plus presoak
TWO-SPEED IDLE TEST	Concentration ppm/pct	Nonloaded test having two speeds: idle and 2,250 rpm
FED THREE-MODE	Concentration ppm/pct	Similar to Key Mode with dynamometer loads simulating the average power as required on the FTP under NADA weight class

Table E-2 presents correlation coefficient for short-test emission measurement procedures on a California 1972 Idle Inspection Fleet Test Program.

E.2 IDLE TEST CORRELATION AND COMMISSION ERRORS

Until there is a sufficient data base that describes the operational characteristics of emission control systems, it is not possible to determine with certainty the adequacy of various emission test procedures in identifying malfunctions of those systems. The relative importance of identifying various types of malfunctions cannot be determined until operating experience with substantial numbers of new and future emission control systems has been gained. However, some general conclusions can be drawn based upon the general characteristics of various test procedures.

The Federal Certification Test Procedures (FTP) is considered the standard for measuring vehicle emission because it is representative of operation in urban areas. The idle-mode emission test, as compared with the FTP, provides for testing a limited number of operating conditions.

The idle-mode test for emission testing is unable to diagnose malfunctions of exhaust gas recirculation (EGR) systems which are currently used by most automobile manufacturers to ensure compliance with the 1973 Federal NO_x emission standards. When the EGR valve is functioning properly, there is no recirculation of the exhaust gas during idle operation; therefore, the system provides no reduction of idle NO_x emissions. A malfunction of the EGR system causing an increase in NO_x emission during loaded operating modes would not result in a concurrent increase in idle-mode emissions. The malfunction would, therefore, remain undetected by an idle test measurement.

A loaded-emission test includes a wide range of operating conditions and would be generally useful in testing future vehicles. However, all current short emission tests are hampered by their inability to measure cold-start emissions, which is important for vehicles equippped with a catalytic or thermal reactor emission control system.

Table E-2

CORRELATION COEFFICIENTS FOR SHORT TEST EMISSION MEASUREMENT PROCEDURES

1972 FTP REGRESSION BEFORE SERVICE

CALIFORNIA IDLE INSPECTION FLEET DATA

		Correlation Coefficient			Standard Error of Estimate Grams Per Mile		
Test Procedure	Emission Measurement	HC	CO	NOx	HC	CO	NOx
Federal Short Cycle	Mass	0.94	0.81	0.74	2.5	32	1.1
Seven Mode Cycle	Mass	0.91	0.70	0.70	3.1	38	1.1
Key Mode (multiple regression)	Mass	0.96	0.81	0.66	2.2	32	1.2
Steady State Modes (mult. regression)	Mass	0.96	0.82	0.71	2.2	32	1.2
Idle Mode	Mass	0.80	0.62	0.15	4.4	42	1.6
Seven Mode Cycle	Volumetric	0.57	0.77	0.43	6.0	34	1.4
Key Mode (multiple regression)	Volumetric	0.79	0.68	0.61	4.5	40	1.3
Steady State Modes (mult. regression)	Volumetric	0.81	0.68	0.63	4.4	40	1.3
Idle Mode	Volumetric	0.35	0.50	0.02	6.8	46	1.6

The evaluation of alternative inspection procedures must also consider their relationship to enforcing the warranty provisions set forth in Section 207 of the Clean Air Act. That section authorizes the EPA to establish regulations requiring automobile manufacturers to warrant the emission control performance of every new motor vehicle for the vehicle's useful life. To implement this provision, Section 207 requires that there be available short-test procedures which aciieve adequate correlation with the FTP. While the definition of adequate correlation is yet to be established, it is clear that those short tests which achieve the highest degree of correlation will most likely satisfy the requirements for adequate correlation. Correlation analyses have consistently shown that for current vehicles, the dynamic (loaded) tests, as a general category, achieve significantly higher correlation with the FTP than do the idle-mode tests. States are not required to consider the feasibility of enforcing the warrantly provisions in the design of their transportation control plans.

The selection of an individual inspection test requires the development of criteria for determining what degree of correlation is adequate to satisfy the warranty provisions. The following analysis provides a qualitative means of making such a determination.

For illustrative purposes, it is assumed that the points marked"a" in Figure E-7 represent the Federal emission standard for all the vehicles in a sample fleet. The points marked "b," "c," "d," and "e," represent hypothetical cut points for a state inspection program. A higher cut point results in a lower rejection rate and, thereby, reduces the fleet emission reduction potential of the program. Any vehicle which is above the inspection cut point, and is to the left of point "a," is defined as an error of commission. There vehicles are erroneously identified as excessive emitters. Any vehicle which fails the inspection criteria and is to the right of point "a" is a valid failure.

The feasibility of enforcing the warranty will be determined by the frequency of commission errors among the vehicles which fail the short test. The probability of a commission error can be reduced by raising the inspection

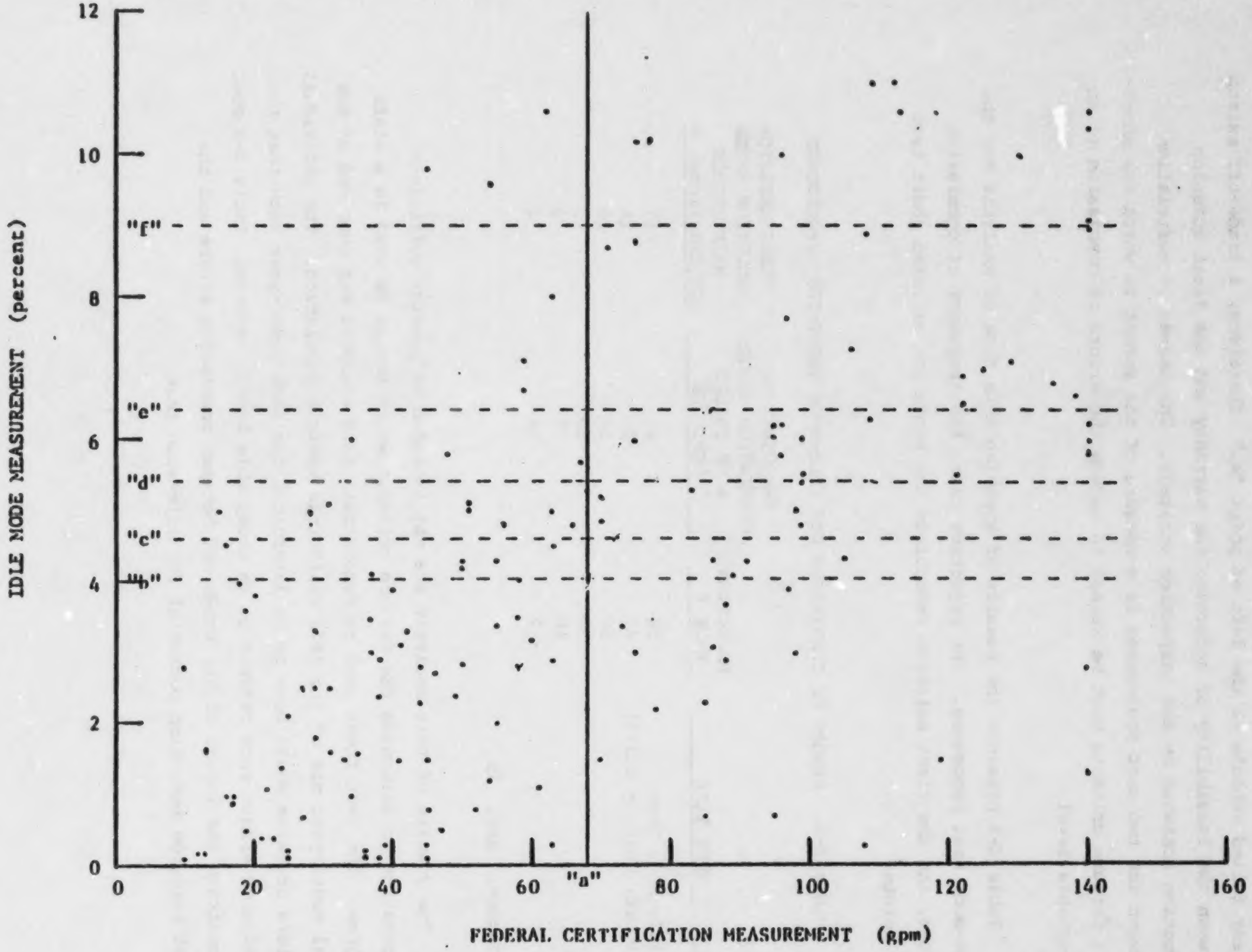


Figure B-7. CARBON MONOXIDE EMISSIONS IDLE MODE TEST CYCLE VERSUS FTP

Correlation Coefficient = .375

test failure criteria. At any cut point, a commission error is still defined as any failed vehicle to the left of point "a." Therefore, a trade-off exists between the feasibility of enforcing the warranty and the fleet emission reduction achieved by the inspection strategy. The degree of correlation between the two test procedures is a measure of the extent to which the short-test failure criteria must be raised to reduce the errors of commission to an acceptable level.

Table E-3 presents the results of applying this type of analysis for the idle-mode test procedure. The rejection rate, the frequency of commission errors, and the fleet emission reductions are shown for selected short test cut points.

Table E-3. ERRORS OF COMMISSION FOR IDLE-MODE SHORT-TEST PROCEDURES

TEST TYPE	REJECTION RATE $	FREQUENCY OF COMMISSION ERRORS % OF FAILED VEHICLES	FLEET EMISSION REDUCTION AFTER MAINTENANCE (CO Emissions) %
Idle Mode Test	50	43	17
(Corr. Coef. = 0.375)	40	40	15
	30	30	10
	20	30	12
	10	27	8
	5	14	4

Source: Ref. 35

The results of this analysis are not intended to provide sufficient information to determine the failure criteria which should be used in a state program. The test fleet used to demonstrate this analysis was composed of the total model-year mix of the 1972 California vehicle population. The individual failure criteria would have to be determined for each model-year such that the commission errors were reduced to an acceptable level. However, Table E-3 does demonstrate the impact of the trade-off between commission errors and the fleet emission reduction potential for idle-mode test.

Appendix F

ADMINISTRATIVE OPTIONS

This section reviews several alternative I/M ownership/operation configurations. The intent is to provide information which will allow a perspective of the following administrative options:

- State-owned/operated centralized facilities
- Contractor-owned/operated centralized facilities
- Privately-owned/operated decentralized facilities

Much of the following information was compiled from past and current I/M programs. For convenience, the information is organized into three subsections:

- Administrative options defined
- Review of background information
- Functional comparisons between administrative options

The first subsection provides working definitions for each administrative option; the second subsection provides an in-depth analysis of each option utilizing past and current I/M programs; the third provides a functional framework of an I/M program for each option by identifying ancillary organizations and their related support services.

Preceding page blank

F.1 ADMINISTRATIVE OPTIONS DEFINED

The three alternative administrative options characterize the operational format of the inspection phase of I/M.* These administrative options are defined as follows:

a) State-owned/operated centralized facilities - Under this program option, a designated public authority would assume complete managerial and operational control of publicly-owned test facilities.

b) Contractor-owned/operated centralized Facilities - A contractor-owned/operated system is an arrangement whereby a corporation, selected through a competitive bid process, assumes operational responsibility for inspection. The contractor and not the State assumes financial responsibility for constructing and operating test centers. Administrative control is still under the responsibility of a centralized public authority.

c) Privately-owned/operated decentralized facilities - In a privately-owned/operated program, a public authority would certify and license qualified establishments (e.g.; service garages, dealerships, and independents) to perform inspections. Managerial and operational authority would be under the direct control of each respective establishment. However, the State would regulate and oversee the program to ensure that I/M requirements and provisions are met. This system provides a network of decentralized inspection and repair facilities which would be certified and controlled by the State.

Conceptually, the selection of a specific administrative option would not have an impact on I/M program emission reduction effectiveness, except in the case of statistical sample operation. However, the specific administrative option chosen will have a substantial effect on capital and operational expenditures, quality assurance, and enforcement. These issues will be discussed in the following subsections using background information from I/M programs currently operating in other states.

---

*Service garages, dealerships, and independents comprising the repair industry will provide the requisite maintenance for failed vehicles identified by the inspection phase.

F.2 BACKGROUND INFORMATION ON CURRENT I/M PROGRAMS

Available background information on I/M programs throughout the country are summarized in Table F-1. Each I/M program is classified as either State-, contractor-, or private garage-operated. For each program type, detailed information such as responsible agency, number of vehicles serviced, stringency factors, emission test, facility site, and estimated costing data (i.e.; capital, operation, inspection cost) are provided under appropriate column headings.

Government I/M programs can be subdivided into either State- or municipally-operated programs. State-operated I/M programs exist in New Jersey and Oregon. The New Jersey Program, using an idle test mode, tests 4 million light-duty vehicles at 38 safety inspection stations. This requires $2.5 million and $1.33 million in capital and operating costs, respectively. The Oregon program which operates leased facilities requires $0.38 million in capital investment and $2.22 million yearly in operating costs.

Municipally-operated programs are found in Ohio (Cincinnati), and Illinois (Chicago). These programs annually inspect 0.2 to 1.0 million vehicles. Ohio has only one station, (four-lane capacity), but intends to expand the program later. Illinois currently operates five test stations and six mobile test units. Capital and operating costs vary with the number of test stations, mobile units, and stringency factor (pass/fail emission parameters).

The only contractor-owned and -operated I/M program is located in Arizona (Maricopa and Pima Counties). The 12 test stations annually process an estimated 1.1 million cars, trucks, and motorcycles using a 30 percent stringency factor with idle test requirements. Capital cost expenditures are estimated at $10 million with annual operating costs approaching $4 million.

Table F-1. EXISTING I/M PROGRAM SUMMARY

PROGRAM TYPE	STATE	ADMINISTRATIVE AGENCY	VEHICLE POP $(X10^6)$	STANDARD		STATION STATUS			COST $(X10^6)$		COST TO MOTORIST
				L.D.V.	H.D.V.	#Lanes	#Sta.	Mobile	Capital[a]	Operating[a]	
I. GOVERNMENT A. State	New Jersey	DMV - EPA	3.9 LDVs	Idle 23%	NA	68	38	1	$2.50 (1972) + safety facil.	1.33 (1975)	$1.50 including safety
B. Municipal	Ohio, Cincinnati	Cincinnati APCD	.200 LDVs	Idle 30%	NA	4	1	None	$13k & safety facil.	13 for 11 positions	$3.75 including safety
	Oregon[b] Portland	Portland Met. Ser. District	.550 LDVs (biennial)	Idle 40%	NA	14	7	1	$.38 Leased facil. (1975)	$2.22	$5
	Illinois, Chicago	Dept. Env. Control	1.0 LDVs	Idle 30-35%	NA	10	5	6	2.0 (1973)	1.45 (1977)	Free
II. CONTRACTOR	Arizona,[c] Maricopa and Pima counties	Dept. of Health	1.1 cars, trucks, and motorcycles	Idle[d] 30%	EPA City	36	12	1	$10.5	$4.0	$5
III. PRIVATE GARAGE	Nevada	Dept. Motor Vehicles and Dept. Human Resources	.500 LDVs	Idle	NA	218 Licensed Private Stations			0.17 (1974)	$.43 approx. (1974)	$10.00-$33.00 (including adjustments)
	Rhode Island	Dept. of Transportation	.500 LDVs	Idle 30%	NA	923 Private Garages + 1 State-Operated challenge lane			1.00 (1977)	Part of Capital cost 1st year	$4

[a] Cost data defined as year. To upgrade costs to present year multiply by appropriate inflation factor.

[b] State of Oregon, Oregon Environmental Quality Commission "Report to the Oregon Legislature on the Motor Vehicle Emission Testing Program," January 14, 1977.

[c] State of Arizona, Bureau of Vehicular Emissions Inspections "Tune-up for Less Emission, - It's Working, Arizona Vehicular Emissions Inspection Program Operations, 1977."

[d] Also test with loaded regimes.

Definitions: DMV - Department of Motor Vehicles.
LDV - Light-Duty Vehicle (GVW <8501 lb.).
HDV - Heavy-Duty Vehicle (GVW >8562 lb.).

In other areas, California initially conducted a 2-year feasibility pilot program (Ref.21), operated by State personnel. Subsequent to this program, California requested competitive bids from private contractors. This contractor-administered program will operate 17 testing facilities at an estimated $14 million in capital outlay, and $22 million (1978 dollars) in annual operating costs (Ref.35).

Currently, Nevada and Rhode Island are the only states that have private garage-operated I/M programs. Rhode Island has an extensive program, testing 0.5 million vehicles at 923 certified private garages. The Nevada program is comparatively smaller, licensing only 218 garages. As expected, the capital cost expenditure for Rhode Island is quite large ($1 million) compared to Nevada ($0.17 million). Unexpectedly, the cost to the motorist is quite high for Nevada ($8.50 to $17) compared to Rhode Island ($4); however, the Nevada program does have vehicle adjustment included in the test requirements.

For each I/M program type, typical problems and their subsequent solutions encountered during the implementation phase are shown in Table F-2. The consensus of opinion suggests that inadequate enforcement, mechanic training, low throughput, and adverse public reaction are problem areas that deserve special attention. In most instances, when adequate mechanic training and public relations programs have been incorporated into the I/M requirements, these problems are minimized or resolved.

F.3 FUNCTIONAL COMPARISONS

A functional framework, rather than a strict organizational plan, identifies potential ancillary organizations and their support services needed for an I/M program (Figure F-1).

A State-administered governmental unit would coordinate all support services provided by program-related organizations. Additional responsibilities should include quality and operational controls of the day-to-day business of the various inspection centers distributed in all air quality nonattainment areas.

Table F-2. TYPICAL I/M PROBLEMS, SOLUTIONS AND ACHIEVEMENTS

PROGRAM TYPE	STATE	PROBLEMS[a]	SOLUTIONS[a]	ACHIEVEMENTS
I. GOVERNMENT-OPERATED				
A. State-Operated	New Jersey	.2-Year Exemption for New Cars	.Legislation Pending	.Nation's Longest On-Going I/M Program
		.Lack Operating Capital Capacity Improvements Cannot be Made	.Funding Has Increased $330,000	.4,700 Garages Now Utilizing Exhaust Analyzers .Private Garage Reinspection Program
		.DMV Resistant to Increased Refailure Rate Expected in Phase III	.No Position Change	
		.Refailure Rate is 25%	.Refailure Rate Now 11%	
	Oregon Portland	.Biennial Inspection Lowers Program Effectiveness, Created Cash Flow and Personnel Problems .Tampering	.Inspection Period Will be Shortened .Trying to Implement An Annual Inspection Cycle, Requires Legislation action	.Estimates Reduction of HC is 14% and CO 7% .Private Garage Acceptance is Increasing
B. Municipal-Operated	Ohio Cincinnati	.Low Throughput .Inadequate Enforcement .No Phase-In Period and No P.R. Program	.Improved Enforcement Led to Increased Throughput .P.R. Program Needed	.Demonstrated Short Lead Time in Adding I/M Program to Safety Program
		.Mechanics Inadequately Trained	.Mechanic Training Program	
	Illinois Chicago	.Less Than 20% of Registered Vehicles Have Been Inspected	.Increased Enforcement Policies .Favor Mandatory Inspection with Three Conditions: 1. Fed. Govt. and Auto Manufacturer's Concurrence On Warrantee Program 2. Auto Manufacturer's Compliance With Existing Statutory Emission Standards 3. I/M Implementation Over Regional Area	.Communication Channels Established with Auto Manufacturers Regarding High Emission Levels of Late Model Vehicles .Nation's First Fully Automated Inspection Program

[a] Information provided by State personnel in each State.

Table F-2. TYPICAL I/M PROBLEMS, SOLUTIONS AND ACHIEVEMENTS (Continued)

PROGRAM TYPE	STATE	PROBLEMS[a]	SOLUTIONS[a]	ACHIEVEMENTS
II. CONTRACTOR-OPERATED	Arizona Maricopa and Pima Counties	.Initial Adverse Public Reaction .Queuing Problems .Tampering .Inadequate Inspector Training	.Expected to Disappear With Increased Efficiency and Better Public Awareness .Increased Contractor Monitoring	.Nation's First Contractor-Operated Program
III. PRIVATE GARAGE-OPERATED	Nevada	.Minimal		.DMV Control of Licensing of Stations and Inspectors .Minimal Cost
	Rhode Island	.Inadequate Training of Garage Mechanics .Some Garages Violated Regulations	.On-Going Mechanic Training Program .Constant Monitoring Needed	.Program Initiated by Governor and Rhode Island DOT With Backing From Executive and Legislative Branches .State-Run Inspection Facility Used as Reference Station

---

[a] Information provided by State personnel.

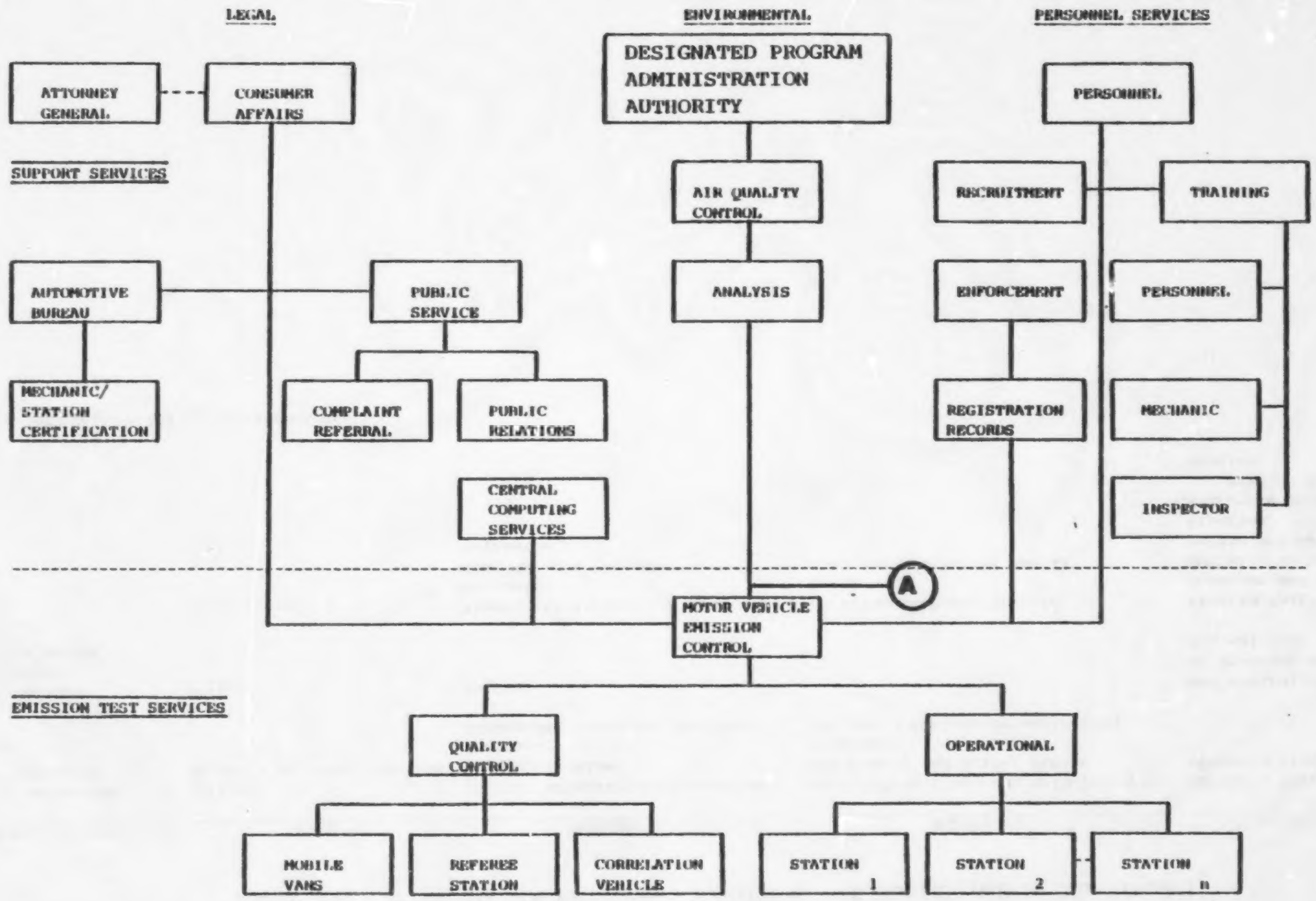

LEGAL
ENVIRONMENTAL
PERSONNEL SERVICES
ATTORNEY GENERAL
CONSUMER AFFAIRS
DESIGNATED PROGRAM ADMINISTRATION AUTHORITY
PERSONNEL
SUPPORT SERVICES
AIR QUALITY CONTROL
RECRUITMENT
TRAINING
AUTOMOTIVE BUREAU
PUBLIC SERVICE
ANALYSIS
ENFORCEMENT
PERSONNEL
MECHANIC/ STATION CERTIFICATION
COMPLAINT REFERRAL
PUBLIC RELATIONS
REGISTRATION RECORDS
MECHANIC
CENTRAL COMPUTING SERVICES
INSPECTOR
A
MOTOR VEHICLE EMISSION CONTROL
EMISSION TEST SERVICES
QUALITY CONTROL
OPERATIONAL
MOBILE VANS
REFEREE STATION
CORRELATION VEHICLE
STATION 1
STATION 2
STATION n

Figure F-1. Functional Administrative Chart

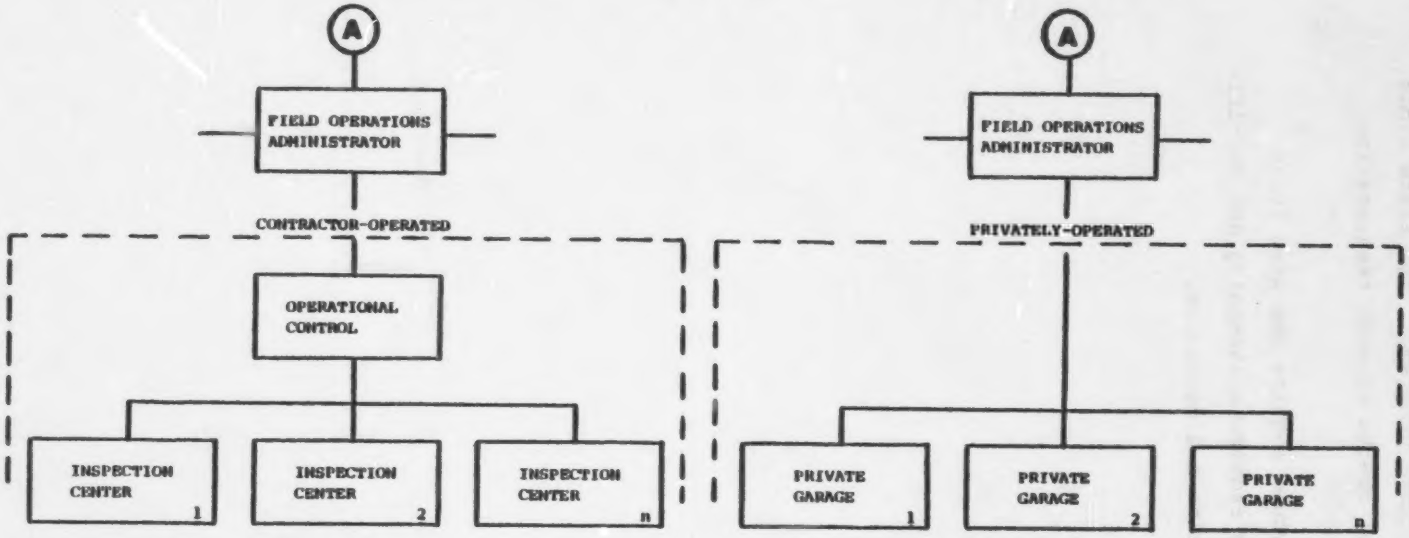

A
FIELD OPERATIONS ADMINISTRATOR
CONTRACTOR-OPERATED
OPERATIONAL CONTROL
INSPECTION CENTER 1
INSPECTION CENTER 2
INSPECTION CENTER n
A
FIELD OPERATIONS ADMINISTRATOR
PRIVATELY-OPERATED
PRIVATE GARAGE 1
PRIVATE GARAGE 2
PRIVATE GARAGE n

Figure F-1a. County Administered

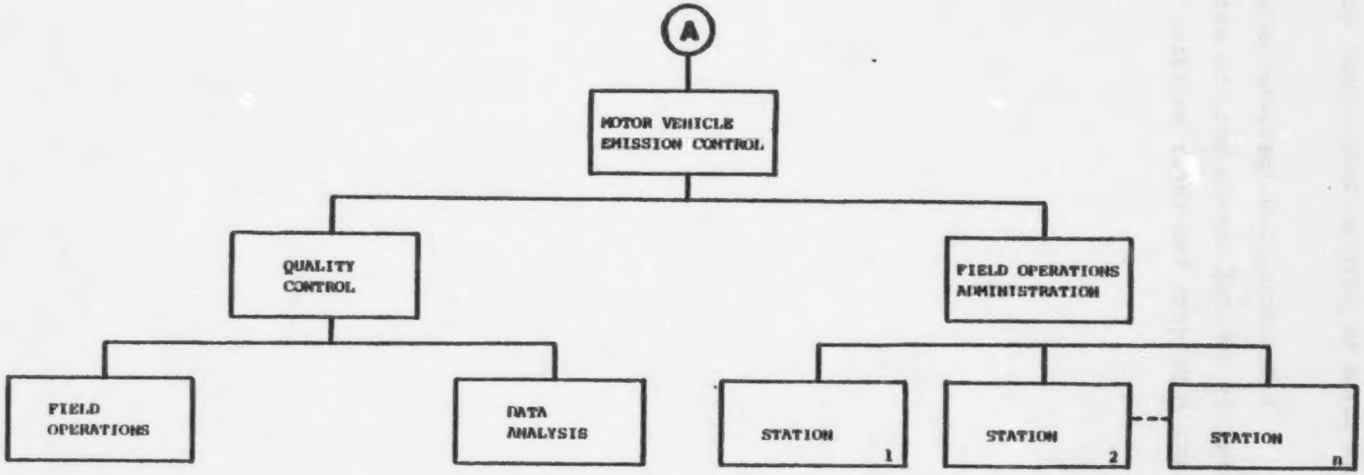

A
MOTOR VEHICLE EMISSION CONTROL
QUALITY CONTROL
FIELD OPERATIONS ADMINISTRATION
FIELD OPERATIONS
DATA ANALYSIS
STATION 1
STATION 2
STATION n

Figure F-1b. Modifications to Reflect Contractor Decentralized (Private Garage) System and County Administered System

The three alternative administrative approaches--state, contractor, and private garage--differ only in the operational format of the total I/M framework. (For instance, a contractor-owned/operated program (Figure F-1b), could be responsible for its own in-house quality control program.) The State would continue to provide independent quality control checks of each test station.

A decentralized (private garage) system would require the same State quality control checks but, in addition, would require a licensing and certification program for their emission test facilities and mechanics.

Appendix G

VEHICLE MILES TRAVELED (VMT) DATA

CHATTANOOGA VEHICLES OWNED

1977	122,467
1982	140,892
1987	174,096

Square Miles = 550

Preceding page blank

CHATTANOOGA
VEHICLE MILES OF TRAVEL
by
FUNCTIONAL CLASS

Year	Interstate	Freeway	Principal Arterial	Minor Arterial	Collector	Local	TOTAL
1977	1,302,343	346,975	1,972,527	503,826	318,456	308,950	4,753,077
1982	1,482,932	395,088	2,246,047	573,689	362,615	351,790	5,412,161
1987	1,663,520	443,201	2,519,565	643,552	406,773	394,630	6,071,241

CHATTANOOGA VEHICLE MIX

INTERSTATE

Average Speed	LDV	LDT 1	LDT 2
42	.751	.084	.084

HDGAS	HDD	MC
.030	.050	.001

FREEWAY

Average Speed	LDV	LDT 1	LDT 2
33	.788	.074	.074

HDGAS	HDD	MC
.025	.033	.006

PRINCIPAL ARTERIAL

Average Speed	LDV	LDT 1	LDT 2
25	.703	.114	.114

HDGAS	HDD	MC
.055	.013	.001

CHATTANOOGA VEHICLE MIX (CONT)

MINOR ARTERIAL

Average Speed	LDV	LDT 1	LDT 2
20	.780	.090	.090
	HDGAS	HDD	MC
	.023	.015	.002

COLLECTOR

Average Speed	LDV	LDT 1	LDT 2
15	.800	.090	.090
	HDGAS	HDD	MC
	.010	.005	.005

LOCAL

Average Speed	LDV	LDT 1	LDT 2
10	.840	.075	.075
	HDGAS	HDD	MC
	.003	.002	.005

KNOXVILLE VEHICLES OWNED

1977	131,451
1982	143,686
1987	155,921

Square Miles = 508

KNOXVILLE-KNOX COUNTY
VEHICLE MILES OF TRAVEL
by
FUNCTIONAL CLASS

Year	Interstate	Freeway	Principal Arterial	Minor Arterial	Collector	Local	TOTAL
1977	1,818,694	34,000	2,840,140	74,857	316,385	360,785	5,444,861
1982	2,120,637	37,533	3,234,128	87,578	362,823	412,867	6,255,566
1987	2,458,598	42,882	3,659,308	100,059	414,531	471,708	7,147,086

KNOXVILLE VEHICLE MIX

INTERSTATE

Average Speed	LDV	LDT 1	LDT 2
40	.738	.074	.074
	HDGAS	HDD	MC
	.035	.064	.005

FREEWAY

Average Speed	LDV	LDT 1	LDT 2
33	.788	.074	.074
	HDGAS	HDD	MC
	.025	.033	.006

PRINCIPAL ARTERIAL

Average Speed	LDV	LDT 1	LDT 2
24	.881	.044	.044
	HDGAS	HDD	MC
	.020	.007	.005

KNOXVILLE VEHICLE MIX (CONT)

MINOR ARTERIAL

Average Speed	LDV	LDT 1	LDT 2
20	.775	.085	.084
	HDGAS	HDD	MC
	.037	.007	.012

COLLECTOR

Average Speed	LDV	LDT 1	LDT 2
15	.818	.070	.070
	HDGAS	HDD	MC
	.020	.004	.018

LOCAL

Average Speed	LDV	LDT 1	LDT 2
10	.833	.007	.006
	HDGAS	HDD	MC
	.015	.002	.020

MEMPHIS VEHICLES OWNED

1977	370,294
1982	409,914
1987	449,534

Square Miles = 755

MEMPHIS
VEHICLE MILES OF TRAVEL
BY FUNCTIONAL CLASSIFICATION

YEAR	INTERSTATE	PRINCIPAL ARTERIAL	MINOR ARTERIAL	COLLECTOR	LOCAL	TOTAL
1977	2,397,159	3,986,960	2,103,531	655,076	1,187,294	10,330,020
1982	3,370,236	4,231,245	2,509,226	774,908	1,414,515	12,300,130
1987	3,910,046	4,908,963	2,911,128	899,025	1,641,078	14,270,240

MEMPHIS VEHICLE MIX

INTERSTATE

Average Speed	LDV	LDT 1	LDT 2
42	.711	.093	.092

	HDGAS	HDD	MC
	.036	.067	.001

FREEWAY

Average Speed	LDV	LDT 1	LDT 2
38	.760	.088	.088

	HDGAS	HDD	MC
	.025	.033	.006

PRINCIPAL ARTERIAL

Average Speed	LDV	LDT 1	LDT 2
28	.770	.087	.088

	HDGAS	HDD	MC
	.040	.014	.001

MEMPHIS VEHICLE MIX (CONT)

MINOR ARTERIAL

Average Speed	LDV	LDT 1	LDT 2
25	.873	.054	.054

HDGAS	HDD	MC
.011	.005	.003

COLLECTOR

Average Speed	LDV	LDT 1	LDT 2
15	.890	.050	.050

HDGAS	HDD	MC
.005	.001	.004

LOCAL

Average Speed	LDV	LDT 1	LDT 2
10	.895	.048	.047

HDGAS	HDD	MC
.004	.001	.005

NASHVILLE VEHICLES OWNED

1977	258,000
1982	293,000
1987	339,000

Square Miles = 508

NASHVILLE
VEHICLE MILES OF TRAVEL
by
FUNCTIONAL CLASS

Year	Interstate	Freeway	Principal Arterial	Minor Arterial	Collector	Local	TOTAL
1977	3,215,335	372,754	3,543,415	400,093	506,126	777,026	8,814,749
1982	3,822,017	428,066	3,985,090	468,835	591,139	896,900	10,192,047
1987	4,753,351	642,011	4,580,502	567,933	716,090	1,086,481	12,346,368

NASHVILLE VEHICLE MIX

INTERSTATE

Average Speed	LDV	LDT 1	LDT 2
42	.749	.079	.070
	HDGAS	**HDD**	**MC**
	.035	.067	.004

FREEWAY

Average Speed	LDV	LDT 1	LDT 2
33	.788	.074	.074
	HDGAS	**HDD**	**MC**
	.025	.033	.006

PRINCIPAL ARTERIAL

Average Speed	LDV	LDT 1	LDT 2
	.742	.100	.093
	HDGAS	**HDD**	**MC**
	.050	.033	.006

NASHVILLE VEHICLE MIX (CONT)

MINOR ARTERIAL

Average Speed	LDV	LDT 1	LDT 2
20	.785	.078	.078

HDGAS	HDD	MC
.048	.008	.003

COLLECTOR

Average Speed	LDV	LDT 1	LDT 2
15	.827	.079	.075

HDGAS	HDD	MC
.006	.003	.010

LOCAL

Average Speed	LDV	LDT 1	LDT 2
10	.850	.066	.066

HDGAS	HDD	MC
.002	.001	.015

Appendix H

DETAILED PROGRAM COSTS FOR OPTION 4

CONSTRUCTION COSTS
OPTION 4, LOCAL COUNTY OPERATED, DAVIDSON COUNTY
(1978 DOLLARS)

COST CONSIDERATION	MANUAL
1. Land and off-site improvement[a]	622,100
2. Facility construction[a]	315,900
3. Instrumentation[a]	48,300
4. Office equipment[a]	12,000
5. Computer[b] (software development)	29,000
TOTAL	1,027,300

[a] Local county cost.

[b] State cost appropriated to local county.

CONSTRUCTION COSTS
OPTION 4, LOCAL COUNTY OPERATED, HAMILTON COUNTY[a]
(1978 DOLLARS)

COST CONSIDERATION	MANUAL
1. Land and off-site improvement[b]	311,000
2. Facility construction[b]	157,900
3. Instrumentation[b]	24,200
4. Office equipment[b]	6,000
5. Computer[c] (software development)	14,000
TOTAL	513,100

[a] Existing facilities not considered in costing of this program.

[b] Local county cost.

[c] State cost appropriated to local county.

Preceding page blank

CONSTRUCTION COSTS
OPTION 4, LOCAL COUNTY OPERATED, KNOX COUNTY
(1978 DOLLARS)

COST CONSIDERATION	MANUAL
1. Land and off-site improvement[a]	311,000
2. Facility construction[a]	157,900
3. Instrumentation[a]	24,200
4. Office equipment[a]	6,000
5. Computer[b] (software development)	15,000
TOTAL	514,100

[a] Local county cost.

[b] State cost appropriated to local county.

CONSTRUCTION COSTS
OPTION 4, LOCAL COUNTY OPERATED, SHELBY COUNTY[a]
(1978 DOLLARS)

COST CONSIDERATION	MANUAL
1. Land and off-site improvement[b]	933,100
2. Facility construction[b]	473,800
3. Instrumentation[b]	72,500
4. Office equipment[b]	18,000
5. Computer[c] (software development)	42,000
TOTAL	1,539,400

[a] Existing facilities not considered in costing of this program.

[b] Local county cost.

[c] State cost appropriated to local county.

CONSTRUCTION COSTS
OPTION 4, CONTRACTOR-OPERATED, DAVIDSON COUNTY
(1978 DOLLARS)

COST CONSIDERATION	MANUAL
1. Land and off-site improvement[a]	622,100
2. Facility construction[a]	315,900
3. Instrumentation[a]	48,300
4. Office equipment[a]	12,000
5. Computer[b] (software development)	29,000
TOTAL	1,027,300

[a] Contractor cost.

[b] State cost appropriated to local county.

CONSTRUCTION COSTS
OPTION 4, CONTRACTOR-OPERATED, HAMILTON COUNTY[a]
(1978 DOLLARS)

COST CONSIDERATION	MANUAL
1. Land and off-site improvement[b]	311,000
2. Facility construction[b]	157,900
3. Instrumentation[b]	24,200
4. Office equipment[b]	6,000
5. Computer[c] (software development)	14,000
TOTAL	513,100

[a] Existing facilities not considered in costing of this program.

[b] Contractor cost.

[c] State cost appropriated to local county.

CONSTRUCTION COSTS
OPTION 4, CONTRACTOR-OPERATED, KNOX COUNTY
(1978 DOLLARS)

COST CONSIDERATION	MANUAL
1. Land and off-site improvement[a]	311,000
2. Facility construction[a]	157,900
3. Instrumentation[a]	24,200
4. Office equipment[a]	6,000
5. Computer[b] (software development)	15,000
TOTAL	514,100

[a] Contractor cost.

[b] State cost appropriated to local county.

CONSTRUCTION COSTS
OPTION 4, CONTRACTOR-OPERATED, SHELBY COUNTY[a]
(1978 DOLLARS)

COST CONSIDERATION	MANUAL
1. Land and off-site improvement[b]	933,100
2. Facility construction[b]	473,800
3. Instrumentation[b]	72,500
4. Office equipment[b]	18,000
5. Computer[c] (software development)	42,000
TOTAL	1,539,400

[a] Existing facilities not considered in costing of this program.

[b] Contractor cost.

[c] State cost appropriated to local county.

CAPITAL COSTS
OPTION 4, PRIVATE GARAGE-OPERATED, DAVIDSON COUNTY
(1978 DOLLARS)

COST CONSIDERATION	MANUAL
1. Instrumentation[a]	640,000
2. Administrative Office Equpment	
● state[b]	2,600
● local county[c]	3,200
3. Quality Control Equipment[c]	
● mobile unit (1)	20,000
● correlation car (1)	10,200
4. Mechanic Training[b]	60
5. Consumer Complaint[c] (1 complaint inspection car)	5,000
6. Vehicle Test Scheduling[b] (software development)	19,600
TOTAL	700,660

[a] Private-garage cost.

[b] State cost appropriated to local county.

[c] Local county cost.

CAPITAL COSTS
OPTION 4, PRIVATE GARAGE-OPERATED, HAMILTON COUNTY
(1978 DOLLARS)

COST CONSIDERATION	MANUAL
1. Instrumentation[a]	352,000
2. Administrative Office Equpment	
● state[b]	1,300
● local county[c]	3,200
3. Quality Control Equipment[c]	
● mobile unit (1)	20,000
● correlation car (1)	10,200
4. Mechanic Training[b]	30
5. Consumer Complaint[c] (1 complaint inspection car)	5,000
6. Vehicle Test Scheduling[b] (software development)	9,500
TOTAL	401,230

[a] Private-garage cost.

[b] State cost appropriated to local county.

[c] Local county cost.

CAPITAL COSTS
OPTION 4, PRIVATE GARAGE-OPERATED, KNOX COUNTY
(1978 DOLLARS)

COST CONSIDERATION	MANUAL
1. Instrumentation[a]	352,000
2. Administrative Office Equpment	
• state[b]	7,300
• local county[c]	3,200
3. Quality Control Equipment[c]	
• mobile unit (1)	20,000
• correlation car (1)	10,200
4. Mechanic Training[b]	30
5. Consumer Complaint[c] (1 complaint inspection car)	5,000
6. Vehicle Test Scheduling[b] (software development)	9,800
TOTAL	401,530

[a] Private-garage cost.

[b] State cost appropriated to local county.

[c] Local county cost.

CAPITAL COSTS
OPTION 4, PRIVATE GARAGE-OPERATED, SHELBY COUNTY
(1978 DOLLARS)

COST CONSIDERATION	MANUAL
1. Instrumentation[a]	968,000
2. Administrative Office Equpment	
• state[b]	3,700
• local county[c]	3,200
3. Quality Control Equipment[c]	
• mobile unit (1)	20,000
• correlation car (1)	10,200
4. Mechanic Training[b]	80
5. Consumer Complaint[c] (1 complaint inspection car)	5,000
6. Vehicle Test Scheduling[b] (software development)	28,100
TOTAL	1,038,280

[a] Private-garage cost.

[b] State cost appropriated to local county.

[c] Local county cost.

OTHER CAPITAL COSTS
OPTION 4, LOCAL COUNTY OPERATED, DAVIDSON COUNTY
(1978 DOLLARS)

COST CONSIDERATION	MANUAL
1. Administrative Office Equpment	
• state[a]	2,600
• local county[b]	3,200
2. Quality Control Equipment[b]	
• mobile unit (1)	20,000
• correlation car (1)	10,200
3. Mechanic Training[a]	60
4. Consumer Complaint[b] (1 complaint inspection car)	5,000
5. Vehicle Test Scheduling[a] (software development)	19,600
TOTAL	60,660

[a] State cost appropriated to local county.

[b] Local county cost.

OTHER CAPITAL COSTS
OPTION 4, LOCAL COUNTY OPERATED, HAMILTON COUNTY
(1978 DOLLARS)

COST CONSIDERATION	MANUAL
1. Administrative Office Equpment	
• state[a]	1,300
• local county[b]	3,200
2. Quality Control Equipment[b]	
• mobile unit (1)	20,000
• correlation car (1)	10,200
3. Mechanic Training[a]	30
4. Consumer Complaint[b] (1 complaint inspection car)	5,000
5. Vehicle Test Scheduling[a] (software development)	9,500
TOTAL	49,230

[a] State cost appropriated to local county.

[b] Local county cost.

OTHER CAPITAL COSTS
OPTION 4, LOCAL COUNTY OPERATED, KNOX COUNTY
(1978 DOLLARS)

COST CONSIDERATION	MANUAL
1. Administrative Office Equpment	
• state[a]	7,300
• local county[b]	3,200
2. Quality Control Equipment[b]	
• mobile unit (1)	20,000
• correlation car (1)	10,200
3. Mechanic Training[a]	30
4. Consumer Complaint[b] (1 complaint inspection car)	5,000
5. Vehicle Test Scheduling[a] (software development)	9,800
TOTAL	49,530

[a] State cost appropriated to local county.

[b] Local county cost.

OTHER CAPITAL COSTS
OPTION 4, LOCAL COUNTY OPERATED, SHELBY COUNTY
(1978 DOLLARS)

COST CONSIDERATION	MANUAL
1. Administrative Office Equpment	
• state[a]	3,700
• local county[b]	3,200
2. Quality Control Equipment[b]	
• mobile unit (1)	20,000
• correlation car (1)	10,200
3. Mechanic Training[a]	80
4. Consumer Complaint[b] (1 complaint inspection car)	5,000
5. Vehicle Test Scheduling[a] (software development)	28,100
TOTAL	70,280

[a] State cost appropriated to local county.

[b] Local county cost.

OTHER CAPITAL COSTS
OPTION 4, CONTRACTOR-OPERATED, DAVIDSON COUNTY
(1978 DOLLARS)

COST CONSIDERATION	MANUAL
1. Administrative Office Equpment	
● state[a]	2,600
● local county[b]	3,200
2. Quality Control Equipment[b]	
● mobile unit (1)	20,000
● correlation car (1)	10,200
3. Mechanic Training[a]	60
4. Consumer Complaint[b] (1 complaint inspection car)	5,000
5. Vehicle Test Scheduling[a] (software development)	19,600
TOTAL	60,660

[a] State cost appropriated to local county.

[b] Local county cost.

OTHER CAPITAL COSTS
OPTION 4, CONTRACTOR-OPERATED, HAMILTON COUNTY
(1978 DOLLARS)

COST CONSIDERATION	MANUAL
1. Administrative Office Equpment	
● state[a]	1,300
● local county[b]	3,200
2. Quality Control Equipment[b]	
● mobile unit (1)	20,000
● correlation car (1)	10,200
3. Mechanic Training[a]	30
4. Consumer Complaint[b] (1 complaint inspection car)	5,000
5. Vehicle Test Scheduling[a] (software development)	9,500
TOTAL	49,230

[a] State cost appropriated to local county.

[b] Local county cost.

OTHER CAPITAL COSTS
OPTION 4, CONTRACTOR-OPERATED, KNOX COUNTY
(1978 DOLLARS)

COST CONSIDERATION	MANUAL
1. Administrative Office Equpment	
• state[a]	7,300
• local county[b]	3,200
2. Quality Control Equipment[b]	
• mobile unit (1)	20,000
• correlation car (1)	10,200
3. Mechanic Training[a]	30
4. Consumer Complaint[b] (1 complaint inspection car)	5,000
5. Vehicle Test Scheduling[a] (software development)	9,800
TOTAL	49,530

[a] State cost appropriated to local county.

[b] Local county cost.

OTHER CAPITAL COSTS
OPTION 4, CONTRACTOR-OPERATED, SHELBY COUNTY
(1978 DOLLARS)

COST CONSIDERATION	MANUAL
1. Administrative Office Equipment	
• state[a]	3,700
• local county[b]	3,200
2. Quality Control Equipment[b]	
• mobile unit (1)	20,000
• correlation car (1)	10,200
3. Mechanic Training[a]	80
4. Consumer Complaint[b] (1 complaint inspection car)	5,000
5. Vehicle Test Scheduling[a] (software development)	28,100
TOTAL	70,280

[a] State cost appropriated to local county.

[b] Local county cost.

INITIAL IMPLEMENTATION COSTS
OPTION 4, LOCAL COUNTY OPERATED, DAVIDSON COUNTY
(1978 DOLLARS)

COST CONSIDERATION	MANUAL
1. Site Selection[a]	7,400
2. Bid Preparation and Evaluation[a]	9,300
3. Design of Facilities[a]	50,000
4. Training Plan Development[a]	3,500
5. Personnel Selection[a]	10,400
6. Document Preparation[a]	7,800
7. Administrative Support[a]	10,000
8. System Certification[a]	500
9. System Integration and Checkout[a]	3,600
TOTAL	102,500

[a] Local county cost.

INITIAL IMPLEMENTATION COSTS
OPTION 4, LOCAL COUNTY OPERATED, HAMILTON COUNTY
(1978 DOLLARS)

COST CONSIDERATION	MANUAL
1. Site Selection[a]	6,200
2. Bid Preparation and Evaluation[a]	9,300
3. Design of Facilities[a]	25,000
4. Training Plan Development[a]	3,500
5. Personnel Selection[a]	10,500
6. Document Preparation[a]	7,800
7. Administrative Support[a]	10,000
8. System Certification[a]	500
9. System Integration and Checkout[a]	1,800
TOTAL	74,600

[a] Local county cost.

INITIAL IMPLEMENTATION COSTS
OPTION 4, LOCAL COUNTY OPERATED, KNOX COUNTY
(1978 DOLLARS)

COST CONSIDERATION	MANUAL
1. Site Selection[a]	6,200
2. Bid Preparation and Evaluation[a]	9,300
3. Design of Facilities[a]	25,000
4. Training Plan Development[a]	3,500
5. Personnel Selection[a]	10,500
6. Document Preparation[a]	7,800
7. Administrative Support[a]	10,000
8. System Certification[a]	500
9. System Integration and Checkout[a]	1,800
TOTAL	74,600

[a] Local county cost.

INITIAL IMPLEMENTATION COSTS
OPTION 4, LOCAL COUNTY OPERATED, SHELBY COUNTY
(1978 DOLLARS)

COST CONSIDERATION	MANUAL
1. Site Selection[a]	8,600
2. Bid Preparation and Evaluation[a]	9,300
3. Design of Facilities[a]	75,000
4. Training Plan Development[a]	3,500
5. Personnel Selection[a]	10,500
6. Document Preparation[a]	7,800
7. Administrative Support[a]	10,000
8. System Certification[a]	500
9. System Integration and Checkout[a]	5,400
TOTAL	135,100

[a] Local county cost.

INITIAL IMPLEMENTATION COSTS
OPTION 4, CONTRACTOR-OPERATED, DAVIDSON COUNTY
(1978 DOLLARS)

COST CONSIDERATION	MANUAL
1. Site Selection[a]	7,400
2. Bid Preparation and Evaluation[a]	9,300
3. Design of Facilities[b]	50,000
4. Training Plan Development[a]	3,500
5. Personnel Selection[b]	10,400
6. Document Preparation[a]	7,800
7. Administrative Support[a]	10,000
8. System Certification[a]	500
9. System Integration and Checkout[b]	3,600
TOTAL	102,500

[a] Local county cost.

[b] Contractor-operated.

INITIAL IMPLEMENTATION COSTS
OPTION 4, CONTRACTOR-OPERATED, HAMILTON
(1978 DOLLARS)

COST CONSIDERATION	MANUAL
1. Site Selection[a]	6,200
2. Bid Preparation and Evaluation[a]	9,300
3. Design of Facilities[b]	25,000
4. Training Plan Development[a]	3,500
5. Personnel Selection[b]	10,500
6. Document Preparation[a]	7,800
7. Administrative Support[a]	10,000
8. System Certification[a]	500
9. System Integration and Checkout[b]	1,800
TOTAL	74,600

[a] Local county cost.

[b] Contractor-operated.

INITIAL IMPLEMENTATION COSTS
OPTION 4, CONTRACTOR-OPERATED, KNOX COUNTY
(1978 DOLLARS)

COST CONSIDERATION	MANUAL
1. Site Selection[a]	6,200
2. Bid Preparation and Evaluation[a]	9,300
3. Design of Facilities[b]	25,000
4. Training Plan Development[a]	3,500
5. Personnel Selection[b]	10,500
6. Document Preparation[a]	7,800
7. Administrative Support[a]	10,000
8. System Certification[a]	500
9. System Integration and Checkout[b]	1,800
TOTAL	74,600

[a] Local county cost.

[b] Contractor-operated.

INITIAL IMPLEMENTATION COSTS
OPTION 4, CONTRACTOR-OPERATED, SHELBY COUNTY
(1978 DOLLARS)

COST CONSIDERATION	MANUAL
1. Site Selection[a]	8,600
2. Bid Preparation and Evaluation[a]	9,300
3. Design of Facilities[b]	75,000
4. Training Plan Development[a]	3,500
5. Personnel Selection[b]	10,500
6. Document Preparation[a]	7,800
7. Administrative Support[a]	10,000
8. System Certification[a]	500
9. System Integration and Checkout[b]	5,400
TOTAL	135,100

[a] Local county cost.

[b] Contractor-Operated.

INITIAL IMPLEMENTATION COSTS
OPTION 4, PRIVATE GARAGE-OPERATED, DAVIDSON COUNTY
(1978 DOLLARS)

COST CONSIDERATION	MANUAL
1. Site Selection	N/A
2. Bid Preparation and Evaluation	N/A
3. Design of Facilities	N/A
4. Training Plan Development[a]	3,500
5. Personnel Selection[a]	10,400
6. Document Preparation[a]	7,800
7. Administrative Support[a]	10,000
8. System Certification[a]	3,600
9. System Integration and Checkout[b]	48,000
TOTAL	83,300

[a] County cost.

[b] Private-garage cost.

INITIAL IMPLEMENTATION COSTS
OPTION 4, PRIVATE GARAGE-OPERATED, HAMILTON COUNTY
(1978 DOLLARS)

COST CONSIDERATION	MANUAL
1. Site Selection	N/A
2. Bid Preparation and Evaluation	N/A
3. Design of Facilities	N/A
4. Training Plan Development[a]	3,500
5. Personnel Selection[a]	10,500
6. Document Preparation[a]	7,800
7. Administrative Support[a]	10,000
8. System Certification[a]	2,000
9. System Integration and Checkout[b]	26,400
TOTAL	60,200

[a] County cost.

[b] Private-garage cost.

INITIAL IMPLEMENTATION COSTS
OPTION 4, PRIVATE GARAGE-OPERATED, KNOX COUNTY
(1978 DOLLARS)

COST CONSIDERATION	MANUAL
1. Site Selection	N/A
2. Bid Preparation and Evaluation	N/A
3. Design of Facilities	N/A
4. Training Plan Development[a]	3,500
5. Personnel Selection[a]	10,500
6. Document Preparation[a]	7,800
7. Administrative Support[a]	10,000
8. System Certification[a]	2,000
9. System Integration and Checkout[b]	26,400
TOTAL	60,200

[a] County cost.

[b] Private-garage cost.

INITIAL IMPLEMENTATION COSTS
OPTION 4, PRIVATE GARAGE-OPERATED, SHELBY COUNTY
(1978 DOLLARS)

COST CONSIDERATION	MANUAL
1. Site Selection	N/A
2. Bid Preparation and Evaluation	N/A
3. Design of Facilities	N/A
4. Training Plan Development[a]	3,500
5. Personnel Selection[a]	15,000
6. Document Preparation[a]	7,800
7. Administrative Support[a]	10,000
8. System Certification[a]	5,500
9. System Integration and Checkout[b]	72,600
TOTAL	114,400

[a] County cost.

[b] Private-garage cost.

CONSUMER PROTECTION COSTS[a]
OPTION 4, LOCAL COUNTY OPERATED, DAVIDSON COUNTY
(1978 DOLLARS)

COST ITEMS	1982	1983	1984	1985	1986	1987	TOTAL
1. Mechanic training[a]	b	b	b	b	b	b	b
2. Public information[b]	67,500	69,000	70,500	72,000	73,500	76,500	429,000
3. Consumer complaint[c]	26,200	26,200	26,200	26,200	26,200	26,200	157,200
4. Vehicle test schedule[b,d]	85,000	85,000	85,000	85,000	85,000	85,000	510,000
TOTAL	178,700	180,200	181,700	183,200	184,700	187,700	1,096,200

[a] Self-supporting operation.

[b] Costs to the State.

[c] Costs to the local county.

[d] Based upon nonintegration with vehicle registration. If integrated with registration would be negligible.

CONSUMER PROTECTION COSTS[a]
OPTION 4, LOCAL COUNTY OPERATED, HAMILTON COUNTY
(1978 DOLLARS)

COST ITEMS	1982	1983	1984	1985	1986	1987	TOTAL
1. Mechanic training[a]	b	b	b	b	b	b	b
2. Public information[b]	32,800	33,600	34,300	35,000	35,700	37,200	208,600
3. Consumer complaint[c]	12,700	12,700	12,700	12,700	12,700	12,700	76,200
4. Vehicle test schedule[b,d]	41,300	41,300	41,300	41,300	41,300	41,300	247,800
TOTAL	86,800	87,600	88,300	89,000	89,700	91,200	532,600

[a] Self-supporting operation.

[b] Costs to the State.

[c] Costs to the local county.

[d] Based upon nonintegration with vehicle registration. If integrated with registration would be negligible.

CONSUMER PROTECTION COSTS[a]
OPTION 4, LOCAL COUNTY OPERATED, KNOX COUNTY
(1978 DOLLARS)

COST ITEMS	1982	1983	1984	1985	1986	1987	TOTAL
1. Mechanic training[a]	b	b	b	b	b	b	b
2. Public information[b]	33,800	34,500	35,300	36,000	36,700	38,300	214,600
3. Consumer complaint[c]	13,100	13,100	13,100	13,100	13,100	13,100	78,600
4. Vehicle test schedule[b,d]	42,500	42,500	42,500	42,500	42,500	42,500	255,000
TOTAL	89,400	90,100	90,900	91,600	92,300	93,900	548,200

[a] Self-supporting operation.

[b] Costs to the State.

[c] Costs to the local county.

[d] Based upon nonintegration with vehicle registration. If integrated with registration would be negligible.

CONSUMER PROTECTION COSTS[a]
OPTION 4, LOCAL COUNTY OPERATED, SHELBY COUNTY
(1978 DOLLARS)

COST ITEMS	1982	1983	1984	1985	1986	1987	TOTAL
1. Mechanic training[a]	b	b	b	b	b	b	b
2. Public information[b]	97,200	99,300	101,400	103,600	105,700	110,000	617,200
3. Consumer complaint[c]	37,700	37,700	37,700	37,700	37,700	37,700	226,200
4. Vehicle test schedule[b,d]	122,200	122,200	122,200	122,200	122,200	122,200	733,200
TOTAL	257,100	259,200	261,300	263,500	265,600	269,900	1,576,600

[a] Self-supporting operation.

[b] Costs to the State.

[c] Costs to the local county.

[d] Based upon nonintegration with vehicle registration. If integrated with registration would be negligible.

CONSUMER PROTECTION COSTS[a]
OPTION 4, CONTRACTOR OPERATED, DAVIDSON COUNTY
(1978 DOLLARS)

COST ITEMS	1982	1983	1984	1985	1986	1987	TOTAL
1. Mechanic training[a]	b	b	b	b	b	b	b
2. Public information[b]	67,500	69,000	70,500	72,000	73,500	76,500	429,000
3. Consumer complaint[c]	26,200	26,200	26,200	26,200	26,200	26,200	157,200
4. Vehicle test schedule[b,d]	85,000	85,000	85,000	85,000	85,000	85,000	510,000
TOTAL	178,700	180,200	181,700	183,200	184,700	187,700	1,096,200

[a] Self-supporting operation.

[b] Costs to the State.

[c] Costs to the local county.

[d] Based upon nonintegration with vehicle registration. If integrated with registration would be negligible.

CONSUMER PROTECTION COSTS[a]
OPTION 4, CONTRACTOR OPERATED, HAMILTON COUNTY
(1978 DOLLARS)

COST ITEMS	1982	1983	1984	1985	1986	1987	TOTAL
1. Mechanic training[a]	b	b	b	b	b	b	b
2. Public information[b]	32,800	33,600	34,300	35,000	35,700	37,200	208,600
3. Consumer complaint[c]	12,700	12,700	12,700	12,700	12,700	12,700	76,200
4. Vehicle test schedule[b,d]	41,300	41,300	41,300	41,300	41,300	41,300	247,800
TOTAL	86,800	87,600	88,300	89,000	89,700	91,200	532,600

[a] Self-supporting operation.

[b] Costs to the State.

[c] Costs to the local county.

[d] Based upon nonintegration with vehicle registration. If integrated with registration would be negligible.

CONSUMER PROTECTION COSTS[a]
OPTION 4, CONTRACTOR OPERATED, KNOX COUNTY
(1978 DOLLARS)

COST ITEMS	1982	1983	1984	1985	1986	1987	TOTAL
1. Mechanic training[a]	b	b	b	b	b	b	b
2. Public information[b]	33,800	34,500	35,300	36,000	36,700	38,300	214,600
3. Consumer complaint[c]	13,100	13,100	13,100	13,100	13,100	13,100	78,600
4. Vehicle test schedule[b,d]	42,500	42,500	42,500	42,500	42,500	42,500	255,000
TOTAL	89,400	90,100	90,900	91,600	92,300	93,900	548,200

[a] Self-supporting operation.

[b] Costs to the State.

[c] Costs to the local county.

[d] Based upon nonintegration with vehicle registration. If integrated with registration would be negligible.

CONSUMER PROTECTION COSTS[a]
OPTION 4, CONTRACTOR OPERATED, SHELBY COUNTY
(1978 DOLLARS)

COST ITEMS	1982	1983	1984	1985	1986	1987	TOTAL
1. Mechanic training[a]	b	b	b	b	b	b	b
2. Public information[b]	97,200	99,300	101,400	103,600	105,700	110,000	617,200
3. Consumer complaint[c]	37,700	37,700	37,700	37,700	37,700	37,700	226,200
4. Vehicle test schedule[b,d]	122,200	122,200	122,200	122,200	122,200	122,200	733,200
TOTAL	257,100	259,200	261,300	263,500	265,600	269,900	1,576,600

[a] Self-supporting operation.

[b] Costs to the State.

[c] Costs to the local county.

[d] Based upon nonintegration with vehicle registration. If integrated with registration would be negligible.

CONSUMER PROTECTION COSTS[a]
OPTION 4, PRIVATE-GARAGE OPERATED, DAVIDSON COUNTY
(1978 DOLLARS)

COST ITEMS	1982	1983	1984	1985	1986	1987	TOTAL
1. Mechanic training[a]	b	b	b	b	b	b	b
2. Public information[b]	67,500	69,000	70,500	72,000	73,500	76,500	429,000
3. Consumer complaint[c]	26,200	26,200	26,200	26,200	26,200	26,200	157,200
4. Vehicle test schedule[b,d]	85,000	85,000	85,000	85,000	85,000	85,000	510,000
TOTAL	178,700	180,200	181,700	183,200	184,700	187,700	1,096,200

[a] Self-supporting operation.

[b] Costs to the State.

[c] Costs to the local county.

[d] Based upon nonintegration with vehicle registration. If integrated with registration would be negligible.

CONSUMER PROTECTION COSTS[a]
OPTION 4, PRIVATE-GARAGE OPERATED, HAMILTON COUNTY
(1978 DOLLARS)

COST ITEMS	1982	1983	1984	1985	1986	1987	TOTAL
1. Mechanic training[a]	b	b	b	b	b	b	b
2. Public information[b]	32,800	33,600	34,300	35,000	35,700	37,200	208,600
3. Consumer complaint[c]	12,700	12,700	12,700	12,700	12,700	12,700	76,200
4. Vehicle test schedule[b,d]	41,300	41,300	41,300	41,300	41,300	41,300	247,800
TOTAL	86,800	87,600	88,300	89,000	89,700	91,200	532,600

[a] Self-supporting operation.

[b] Costs to the State.

[c] Costs to the local county.

[d] Based upon nonintegration with vehicle registration. If integrated with registration would be negligible.

CONSUMER PROTECTION COSTS[a]
OPTION 4, PRIVATE-GARAGE OPERATED, KNOX COUNTY
(1978 DOLLARS)

COST ITEMS	1982	1983	1984	1985	1986	1987	TOTAL
1. Mechanic training[a]	b	b	b	b	b	b	b
2. Public information[b]	33,800	34,500	35,300	36,000	36,700	38,300	214,600
3. Consumer complaint[c]	13,100	13,100	13,100	13,100	13,100	13,100	78,600
4. Vehicle test schedule[b,d]	42,500	42,500	42,500	42,500	42,500	42,500	255,000
TOTAL	89,400	90,100	90,900	91,600	92,300	93,900	548,200

[a] Self-supporting operation.

[b] Costs to the State.

[c] Costs to the local county.

[d] Based upon nonintegration with vehicle registration. If integrated with registration would be negligible.

CONSUMER PROTECTION COSTS[a]
OPTION 4, PRIVATE-GARAGE OPERATED, SHELBY COUNTY
(1978 DOLLARS)

COST ITEMS	1982	1983	1984	1985	1986	1987	TOTAL
1. Mechanic training[a]	b	b	b	b	b	b	b
2. Public information[b]	97,200	99,300	101,400	103,600	105,700	110,000	617,200
3. Consumer complaint[c]	37,700	37,700	37,700	37,700	37,700	37,700	226,200
4. Vehicle test schedule[b,d]	122,200	122,200	122,200	122,200	122,200	122,200	733,200
TOTAL	257,100	259,200	261,300	263,500	265,600	269,900	1,576,600

[a] Self-supporting operation.

[b] Costs to the State.

[c] Costs to the local county.

[d] Based upon nonintegration with vehicle registration. If integrated with registration would be negligible.

OPERATING COSTS
OPTION 4, LOCAL COUNTY OPERATED, DAVIDSON COUNTY
(1978 DOLLARS)

COST ITEMS	1982	1983	1984	1985	1986	1987	TOTAL
1. Facility Operation[a]							
a. Personnel	379,000	389,000	399,000	409,000	419,000	429,000	2,424,000
b. Maintenance, Supply, and Utility Costs	31,200	31,200	31,200	31,200	31,200	31,200	187,200
c. Equipment Maintenance	3,000	3,000	3,000	3,000	3,000	3,000	18,000
2. Support							
a. Administration							
• state[b]	39,600	39,600	39,600	39,600	39,600	39,600	237,600
• local county	47,400	47,400	47,400	47,400	47,400	47,400	284,400
b. Data Analyses[b]	13,100	13,100	13,100	13,100	13,100	13,100	78,600
c. Training							
• state[b]	2,200	2,200	2,200	2,200	2,200	2,200	13,200
• local county	800	800	800	800	800	800	4,800
3. Quality Control Costs[a]							
a. Personnel	18,500	18,500	18,500	18,500	18,500	18,500	111,000
b. Supply.	300	300	300	300	300	300	1,800
c. Maintenance of mobile unit and correlation vehicle	5,300	5,300	5,300	5,300	5,300	5,300	31,800
TOTAL	540,400	550,400	560,400	570,400	580,400	590,400	3,392,400

[a] Local county costs.

[b] State cost appropriated to local county.

OPERATING COSTS
OPTION 4, LOCAL COUNTY OPERATED, HAMILTON COUNTY
(1978 DOLLARS)

COST ITEMS	1982	1983	1984	1985	1986	1987	TOTAL
1. Facility Operation[a]							
a. Personnel	189,500	194,500	199,500	204,500	209,500	214,500	1,212,000
b. Maintenance, Supply, and Utility Costs	15,600	15,600	15,600	15,600	15,600	15,600	93,600
c. Equipment Maintenance	1,500	1,500	1,500	1,500	1,500	1,500	9,000
2. Support							
a. Administration							
● state[b]	19,400	19,400	19,400	19,400	19,400	19,400	116,400
● local county	47,400	47,400	47,400	47,400	47,400	47,400	284,400
b. Data Analyses[b]	6,400	6,400	6,400	6,400	6,400	6,400	38,400
c. Training							
● state[b]	2,200	2,200	2,200	2,200	2,200	2,200	13,200
● local county	800	800	800	800	800	800	4,800
3. Quality Control Costs[a]							
a. Personnel	18,500	18,500	18,500	18,500	18,500	18,500	111,000
b. Supply	300	300	300	300	300	300	1,800
c. Maintenance of mobile unit and correlation vehicle	5,300	5,300	5,300	5,300	5,300	5,300	31,800
TOTAL	306,900	311,900	316,900	321,900	326,900	331,900	1,916,400

[a] Local county costs.

[b] State cost appropriated to local county.

OPERATING COSTS
OPTION 4, LOCAL COUNTY OPERATED, KNOX COUNTY
(1978 DOLLARS)

COST ITEMS	1982	1983	1984	1985	1986	1987	TOTAL
1. Facility Operation[a]							
a. Personnel	189,500	194,500	199,500	204,500	209,500	214,500	1,212,000
b. Maintenance, Supply, and Utility Costs	15,600	15,600	15,600	15,600	15,600	15,600	93,600
c. Equipment Maintenance	1,500	1,500	1,500	1,500	1,500	1,500	9,000
2. Support							
a. Administration							
• state[b]	19,700	19,700	19,700	19,700	19,700	19,700	118,200
• local county	47,400	47,400	47,400	47,400	47,400	47,400	284,400
b. Data Analyses[b]	6,500	6,500	6,500	6,500	6,500	6,500	39,000
c. Training							
• state[b]	2,200	2,200	2,200	2,200	2,200	2,200	13,200
• local county	800	800	800	800	800	800	4,800
3. Quality Control Costs[a]							
a. Personnel	18,500	18,500	18,500	18,500	18,500	18,500	111,000
b. Supply	300	300	300	300	300	300	1,800
c. Maintenance of mobile unit and correlation vehicle	5,300	5,300	5,300	5,300	5,300	5,300	31,800
TOTAL	307,300	312,300	317,300	322,300	327,300	332,300	1,918,800

[a] Local county costs.

[b] State cost appropriated to local county.

OPERATING COSTS
OPTION 4, LOCAL COUNTY OPERATED, SHELBY COUNTY
(1978 DOLLARS)

COST ITEMS	1982	1983	1984	1985	1986	1987	TOTAL
1. Facility Operation[a]							
a. Personnel	568,500	583,200	598,500	613,500	628,500	643,500	3,636,000
b. Maintenance, Supply, and Utility Costs	46,800	46,800	46,800	46,800	46,800	46,800	280,800
c. Equipment Maintenance	4,500	4,500	4,500	4,500	4,500	4,500	27,000
2. Support							
a. Administration							
● state[b]	56,900	56,900	56,900	56,900	56,900	56,900	341,400
● local county	47,400	47,400	47,400	47,400	47,400	47,400	284,400
b. Data Analyses[b]	18,900	18,900	18,900	18,900	18,900	18,900	113,400
c. Training							
● state[b]	2,200	2,200	2,200	2,200	2,200	2,200	13,200
● local county	800	800	800	800	800	800	4,800
3. Quality Control Costs[a]							
a. Personnel	18,500	18,500	18,500	18,500	18,500	18,500	111,000
b. Supply	300	300	300	300	300	300	1,800
c. Maintenance of mobile unit and correlation vehicle	5,300	5,300	5,300	5,300	5,300	5,300	31,800
TOTAL	770,100	785,100	800,100	815,100	830,100	845,100	4,845,600

[a] Local county costs.

[b] State cost appropriated to local county.

OPERATING COSTS
OPTION 4, PRIVATE-GARAGE OPERATED, DAVIDSON COUNTY
(1978 DOLLARS)

COST ITEMS	1982	1983	1984	1985	1986	1987	TOTAL
1. Facility Operation[a]							
a. Personnel	285,500	293,000	300,600	308,100	315,700	323,200	1,826,100
2. Support							
a. Administration							
● state[b]	39,600	39,600	39,600	39,600	39,600	39,600	237,600
● local county	47,400	47,400	47,400	47,400	47,400	47,400	284,400
b. Data Analyses[b]	13,100	13,100	13,100	13,100	13,100	13,100	78,600
c. Training							
● state[b]	2,200	2,200	2,200	2,200	2,200	2,200	13,200
● local county	800	800	800	800	800	800	4,800
3. Quality Control Costs[c]							
a. Personnel	18,500	18,500	18,500	18,500	18,500	18,500	111,000
b. Supply	300	300	300	300	300	300	1,800
c. Maintenance of mobile unit and correlation vehicle	5,300	5,300	5,300	5,300	5,300	5,300	31,800
TOTAL	412,700	420,200	427,800	435,300	442,900	450,400	2,589,300

[a] Private-garage costs.

[b] State cost appropriated to local county.

[c] Local county costs.

OPERATING COSTS
OPTION 4, PRIVATE-GARAGE OPERATED, HAMILTON COUNTY
(1978 DOLLARS)

COST ITEMS	1982	1983	1984	1985	1986	1987	TOTAL
1. Facility Operation[a]							
a. Personnel	139,600	143,300	147,000	150,700	154,300	158,000	892,900
2. Support							
a. Administration							
● state[b]	19,400	19,400	19,400	19,400	19,400	19,400	116,400
● local county	47,400	47,400	47,400	47,400	47,400	47,400	284,400
b. Data Analyses[b]	6,400	6,400	6,400	6,400	6,400	6,400	38,400
c. Training							
● state[b]	2,200	2,200	2,200	2,200	2,200	2,200	13,200
● local county	800	800	800	800	800	800	4,800
3. Quality Control Costs[c]							
a. Personnel	18,500	18,500	18,500	18,500	18,500	18,500	111,000
b. Supply	300	300	300	300	300	300	1,800
c. Maintenance of mobile unit and correlation vehicle	5,300	5,300	5,300	5,300	5,300	5,300	31,800
TOTAL	239,900	243,600	247,300	251,000	254,600	258,300	1,494,700

[a] Private-garage costs.

[b] State cost appropriated to local county.

[c] Local county costs.

OPERATING COSTS
OPTION 4, PRIVATE-GARAGE OPERATED, KNOX COUNTY
(1978 DOLLARS)

COST ITEMS	1982	1983	1984	1985	1986	1987	TOTAL
1. Facility Operation[a]							
a. Personnel	142,300	146,100	149,800	153,600	157,300	161,100	910,200
2. Support							
a. Administration							
• state[b]	19,700	19,700	19,700	19,700	19,700	19,700	118,200
• local county	47,400	47,400	47,400	47,400	47,400	47,400	284,400
b. Data Analyses[b]	6,500	6,500	6,500	6,500	6,500	6,500	39,000
c. Training							
• state[b]	2,200	2,200	2,200	2,200	2,200	2,200	13,200
• local county	800	800	800	800	800	800	4,800
3. Quality Control Costs[c]							
a. Personnel	18,500	18,500	18,500	18,500	18,500	18,500	111,000
b. Supply	300	300	300	300	300	300	1,800
c. Maintenance of mobile unit and correlation vehicle	5,300	5,300	5,300	5,300	5,300	5,300	31,800
TOTAL	243,000	246,800	250,500	254,300	258,000	261,800	1,514,400

[a] Private-garage costs.

[b] State cost appropriated to local county.

[c] Local county costs.

OPERATING COSTS
OPTION 4, PRIVATE-GARAGE OPERATED, SHELBY COUNTY
(1978 DOLLARS)

COST ITEMS	1982	1983	1984	1985	1986	1987	TOTAL
1. Facility Operation[a]							
a. Personnel	410,100	420,900	431,800	442,600	453,400	464,200	2,623,000
2. Support							
a. Administration							
• state[b]	56,900	56,900	56,900	56,900	56,900	56,900	341,400
• local county	47,400	47,400	47,400	47,400	47,400	47,400	284,400
b. Data Analyses[b]	18,900	18,900	18,900	18,900	18,900	18,900	113,400
c. Training							
• state[b]	2,200	2,200	2,200	2,200	2,200	2,200	13,200
• local county	800	800	800	800	800	800	4,800
3. Quality Control Costs[c]							
a. Personnel	18,500	18,500	18,500	18,500	18,500	18,500	111,000
b. Supply	300	300	300	300	300	300	1,800
c. Maintenance of mobile unit and correlation vehicle	5,300	5,300	5,300	5,300	5,300	5,300	31,800
TOTAL	560,400	571,200	582,100	592,900	603,700	614,500	3,524,800

[a] Private-garage costs.

[b] State cost appropriated to local county.

[c] Local county costs.

OPERATING COSTS
OPTION 4, CONTRACTOR OPERATED, DAVIDSON COUNTY
(1978 DOLLARS)

COST ITEMS	1982	1983	1984	1985	1986	1987	TOTAL
1. Facility Operation[a]							
a. Personnel	379,000	389,000	399,000	409,000	419,000	429,000	2,424,000
b. Maintenance, Supply, and Utility Costs	46,200	46,200	46,200	46,200	46,200	46,200	277,200
c. Equipment Maintenance	3,000	3,000	3,000	3,000	3,000	3,000	18,000
2. Support							
a. Administration							
● state[b]	39,600	39,600	39,600	39,600	39,600	39,600	237,600
● local county	47,400	47,400	47,400	47,400	47,400	47,400	284,400
b. Data Analyses[b]	13,100	13,100	13,100	13,100	13,100	13,100	78,600
c. Training							
● state[b]	2,200	2,200	2,200	2,200	2,200	2,200	13,200
● local county	800	800	800	800	800	800	4,800
3. Quality Control Costs[c]							
a. Personnel	18,500	18,500	18,500	18,500	18,500	18,500	111,000
b. Supply	300	300	300	300	300	300	1,800
c. Maintenance of mobile unit and correlation vehicle	5,300	5,300	5,300	5,300	5,300	5,300	31,800
TOTAL	555,400	565,400	575,400	585,400	595,400	605,400	3,482,400

[a] Contractor operated costs.

[b] State cost appropriated to local county.

[c] Local county costs.

OPERATING COSTS
OPTION 4, CONTRACTOR OPERATED, HAMILTON COUNTY
(1978 DOLLARS)

COST ITEMS	1982	1983	1984	1985	1986	1987	TOTAL
1. Facility Operation[a]							
a. Personnel	189,500	194,500	199,500	204,500	209,500	214,500	1,212,000
b. Maintenance, Supply, and Utility Costs	23,100	23,100	23,100	23,100	23,100	23,100	138,600
c. Equipment Maintenance	1,500	1,500	1,500	1,500	1,500	1,500	9,000
2. Support							
a. Administration							
● state[b]	19,400	19,400	19,400	19,400	19,400	19,400	116,400
● local county	47,400	47,400	47,400	47,400	47,400	47,400	284,400
b. Data Analyses[b]	6,400	6,400	6,400	6,400	6,400	6,400	38,400
c. Training							
● state[b]	2,200	2,200	2,200	2,200	2,200	2,200	13,200
● local county	800	800	800	800	800	800	4,800
3. Quality Control Costs[c]							
a. Personnel	18,500	18,500	18,500	18,500	18,500	18,500	111,000
b. Supply	300	300	300	300	300	300	1,800
c. Maintenance of mobile unit and correlation vehicle	5,300	5,300	5,300	5,300	5,300	5,300	31,800
TOTAL	314,400	319,400	324,400	329,400	334,400	339,400	1,961,400

[a] Contractor operated costs.

[b] State cost appropriated to local county.

[c] Local county costs.

OPERATING COSTS
OPTION 4, CONTRACTOR OPERATED, KNOX COUNTY
(1978 DOLLARS)

COST ITEMS	1982	1983	1984	1985	1986	1987	TOTAL
1. Facility Operation[a]							
a. Personnel	189,500	194,500	199,500	204,500	209,500	214,500	1,212,000
b. Maintenance, Supply, and Utility Costs	23,100	23,100	23,100	23,100	23,100	23,100	138,600
c. Equipment Maintenance	1,500	1,500	1,500	1,500	1,500	1,500	9,000
2. Support							
a. Administration							
● state[b]	19,700	19,700	19,700	19,700	19,700	19,700	118,200
● local county	47,400	47,400	47,400	47,400	47,400	47,400	284,400
b. Data Analyses[b]	6,500	6,500	6,500	6,500	6,500	6,500	39,000
c. Training							
● state[b]	2,200	2,200	2,200	2,200	2,200	2,200	13,200
● local county	800	800	800	800	800	800	4,800
3. Quality Control Costs[c]							
a. Personnel	18,500	18,500	18,500	18,500	18,500	18,500	111,000
b. Supply	300	300	300	300	300	300	1,800
c. Maintenance of mobile unit and correlation vehicle	5,300	5,300	5,300	5,300	5,300	5,300	31,800
TOTAL	314,800	319,800	324,800	329,800	334,800	339,800	1,963,800

[a] Contractor operated costs.

[b] State cost appropriated to local county.

[c] Local county costs.

OPERATING COSTS
OPTION 4, CONTRACTOR OPERATED, SHELBY COUNTY
(1978 DOLLARS)

COST ITEMS	1982	1983	1984	1985	1986	1987	TOTAL
1. Facility Operation[a]							
a. Personnel	568,500	583,500	598,500	613,500	628,500	643,500	3,636,000
b. Maintenance, Supply, and Utility Costs	69,300	69,300	69,300	69,300	69,300	69,300	415,800
c. Equipment Maintenance	4,500	4,500	4,500	4,500	4,500	4,500	27,000
2. Support							
a. Administration							
● state[b]	56,900	56,900	56,900	56,900	56,900	56,900	341,400
● local county	47,400	47,400	47,400	47,400	47,400	47,400	284,400
b. Data Analyses[b]	18,900	18,900	18,900	18,900	18,900	18,900	113,400
c. Training							
● state[b]	2,200	2,200	2,200	2,200	2,200	2,200	13,200
● local county	800	800	800	800	800	800	4,800
3. Quality Control Costs[c]							
a. Personnel	18,500	18,500	18,500	18,500	18,500	18,500	111,000
b. Supply	300	300	300	300	300	300	1,800
c. Maintenance of mobile unit and correlation vehicle	5,300	5,300	5,300	5,300	5,300	5,300	31,800
TOTAL	792,600	807,600	822,600	837,600	852,600	867,600	4,980,600

[a] Contractor operated costs.

[b] State cost appropriated to local county.

[c] Local county costs.

Appendix I

COST AND FEE CALCULATIONS

This appendix provides the detailed method used in calculating annual costs and fees.

TIME VALUE OF MONEY

Analysis of economic activities requires comparison of sums of money (cash flows) at various points in time. This means we need methods which will enable us to take into account the time value of money (interest).

The values of sums of money at different points in time depend upon the interest rate and the time spans. A sum of money today is not equivalent to the same sum ten years later unless interest were assumed at the unrealistic rate of zero.

The present value (P) of a future sum (S) that yields n years from now is calculated as follows:

$$P = S \times \left[\frac{1}{1+i}\right]^n$$

where i is the interest rate.

Another useful concept is the annualized worth of a present sum. For example, if a borrower applies loan of P dollars from a bank, the interest is i.

Preceding page blank

What is the yearly uniform payment that he has to pay back in n years? This type of question can be answered with the following formula:

$$R = P\left[\frac{i(1+i)^n}{(1+i)^n-1}\right]$$

where:

R is the uniform payment per year
P is the present sum
n is the number of years
i is the interest.

CONSUMER FEE CALCULATION

The consumer fee, F_c is calculated by dividing total uniform annualized cost by the average number of vehicles inspected per year. This fee is designed to defray all of the costs, except certain state overhead expenses incurred on the implementation of an I/M program.

INFLATION EFFECT

The above mentioned fee is in constant dollars. To consider the inflation effect, an adjustment factor must be applied.

Let the projected annual inflation rate be i. The consumer fee in constant dollars is F_c. Let the uniform fee in actual dollar be F_a. The relationship between F_a and F_c can be derived as follows:

$$F_a = \frac{(F_c + F_c(1+i) + F_c(1+i)^2 + --- + F_c(1+i)^{n-1})\ (1+i)^{\gamma-1}}{n}$$

$$= F_c \times \frac{(1+i)^n - 1}{n \times i}\ (1+i)^{\gamma-1}$$

where $\checkmark$ is the number of years to the starting year of I/M program, and n is the program period. The term

$$\frac{(1+i)^{n} -1}{n \times i} (1+i)^{\checkmark-1}$$

is the adjustment factor for inflation.

For example, if an I/M program starts in 1982 and continues for 10 years, the adjustment factor to 1978 constant dollars with 7 percent inflation rate is calculated as follows:

$$(1+0.07)^{4} \times ((1+0.007)^{10} -1/10 \times 0.07 = 1.81$$